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Featuring

The 1928 Joint Standard Building Code

Pollution of Streams by Industrial Wastes

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THE 1928 JOINT STANDARD BUILDING CODE PROPOSED BY THE AMERICAN CONCRETE INSTITUTE

(Papers and Discussions presented at a Meeting of the Designers Section of the Boston Society of Civil Engineers, March 13, 1929)

THE EVOLUTION OF MODERN BUILDING REGULATIONS FOR REINFORCED CONCRETE

BY R. R. ZIPPRODT *

To those who have not made a thorough study of building codes and their preparation, it may appear as though it should not be a difficult matter to draw up a code that would be simple, both in text and practical operation. In practice, however, this is not ordinarily the case. There are so many of the materials used in present-day building construction which require a statement of the special conditions governing their use in order to avoid unfair discrimination; so many design matters which must be left to the engineer's better judgment; and so many more or less minor details which must be covered by code provisions in order to avoid the necessity for special rulings or interpretations, that any code soon becomes quite involved.

In the case of regulations to govern reinforced concrete construction, the problem assumes additional complexity due to three factors: first, the newness of reinforced concrete construction when compared to other forms of construction which have existed from the beginning of time; second, the numerous ways in which reinforced concrete has

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* Structural and Technical Bureau, Portland Cement Association, Chicago.

been adapted to almost innumerable types of construction; and third, the rapidly increasing and extensive test data which are becoming available, and which are constantly adding to our knowledge of the art of producing good concrete.

The present Joint Code of the American Concrete Institute and the Concrete Reinforcing Steel Institute is the outgrowth of almost twenty-five years of serious effort on the part of the properly qualified bodies to provide a set of regulations which will be thoroughly in accord with the latest advances in the art of making concrete, and, at the same time, be not too difficult of application and enforcement.

The first efforts leading to the formulation of a code were taken on June 17, 1904, at Atlantic City, New Jersey, by the union of special committees appointed in 1903 and 1904 by the American Society of Civil Engineers, American Society for Testing Materials, American Railway Engineering Association, and the Portland Cement Association. This group, consisting of five representatives from each of the above organizations, constituted the Joint Committee on Concrete and Reinforced Concrete. In 1915 the American Concrete Institute was added by invitation of the original Joint Committee.

Progress reports were made by this Committee in 1909 and 1912. A final report was adopted and submitted to the constituent organizations on July 1, 1916. The purpose of this committee was to prepare a Recommended Practice for Concrete and Reinforced Concrete; but its final report stated: "The report is not a specification, but may be used as a basis for specifications."

The present Joint Committee was organized through the efforts of the Committee on Reinforced Concrete of the American Society for Testing Materials. This Committee, on June 27, 1917, requested that an invitation be issued to the co-operating organization of the old Joint Committee to form a Joint Committee on Specifications for Concrete and Reinforced Concrete. The organization meeting of the new Committee was held at the Engineers' Club in Philadelphia on February 11, 1920.

On June 4, 1921, the Committee submitted to its constituent organizations Tentative Specifications for Concrete and Reinforced Concrete. In order to determine whether or not these Specifications were practical, particularly in regard to provisions for the control of the quality of concrete in the field, a number of series of tests were made. These included tests on the concrete used in the construction of one of the buildings of the Victor Talking Machine Company, Camden, New Jersey, and for the construction of the piers of the Newark Bay bridge of the Central Railroad of New Jersey.

After carefully reviewing the results of the above tests, as well as the criticisms and discussions which its Tentative Specifications invoked, and making such modifications as seemed desirable, the Committee presented the present Standard Specifications for Concrete and Reinforced Concrete on August 14, 1924. This document marked a distinct advance in the design of reinforced concrete. For the first time an attempt was made to control the quality of the concrete for design purposes, and also to fix the stresses used in design as a percentage of the ultimate compressive strength of the concrete.

Upon the appearance of the 1924 Joint Committee Report, the Committee on Reinforced Concrete Building Design and Specifications of the American Concrete Institute was commissioned by its Board of Directors to prepare a set of building regulations, using the 1924 Report as a basis. In 1925 such regulations were submitted to the Institute. After making some modifications, these regulations were adopted in 1927 as a Tentative Standard by the American Concrete Institute.

Just about this time, also, the Concrete Reinforcing Steel Institute adopted a similar set of regulations, which were in substantial agreement with those of the American Concrete Institute, but differing considerably in form and in some of the lesser items. Both organizations realized the desirability of having a single document which might be included in, and be made a part of, any building code. Accordingly, Committee E-1 of the American Concrete Institute and the Committee on Engineering Practice of the Concrete Reinforcing Steel Institute met jointly and developed the present Building Regulations for Reinforced Concrete. These were adopted as a Tentative Standard by the American Concrete Institute on February 29, 1928, and by the Reinforcing Steel Institute on March 19, 1928.

These regulations are not merely incidental to committee activities, but are the result of careful study by many individuals. One purpose has been predominant, — that of providing building regulations which would embody the latest recognized advances in reinforced concrete design and construction. In the formulation of these regulations, the two Committees have had the benefit of the extended deliberations and of the wisdom of the several Joint Committees which have preceded it, and of the long years of experience and practice which are represented by the membership of the combined committee.

It will undoubtedly prove of interest to those who are here, to know to what extent this Joint Code is being adopted by other cities whenever the question of a revision of their present building code is brought up.

In this connection, then, be it known that the following cities now permit the use of the higher unit stresses, *including* 20,000 pounds per square inch on *intermediate grade steel bars*, either *by actual inclusion* as a part of the building code, or *by special permission* of the Building Commissioner. These cities are:

Omaha, Nebraska
New Orleans, Louisiana
Jackson, Mississippi
Oklahoma City, Oklahoma
Birmingham, Alabama
Meridian, Mississippi
Beaumont, Texas
Port Arthur, Texas
Shreveport, Louisiana
Monroe, Louisiana
Eldorado, Arkansas
Richmond, Virginia
Blairsville, Pennsylvania
Indianapolis, Indiana
Cincinnati, Ohio

The following permit a unit stress of 20,000 pounds per square inch on hard and rail steel bars: Pacific Coast Building Officials Uniform Code, Detroit, Michigan, and St. Louis, Missouri; and the following a unit stress of 20,000 pounds on hard grade steel: Seattle, Washington, and Memphis, Tennessee.

The following largest cities of this country have used the Joint Code as the basis for the revision of their present codes. They are Philadelphia, which has gotten well along with its revision; New York, which has just begun its work, but which is modelling its section on reinforced concrete after the Joint Code; and Chicago, which has included the Joint Code, as it is, as its section on reinforced concrete. With such cities as these pointing the way, it must be only a matter of a short time before the other large cities will see the advisability of revising their codes to accord with the Joint Code.

In addition, the Joint Code has been used as the model for the Pacific Coast Building Officials Uniform Code (by which all Pacific Coast cities are governed) and by the Southeastern and Southwestern Building Officials Conferences (which cover the majority of the Southern States) and which have only very recently been organized.

All these things point the way most definitely to the adoption in the near future of a standard building code for the Nation; and it is our prediction that, with the progress which has been made since this Joint Code came into being, this time is not very far distant.

CONCRETE MATERIALS, TESTS, QUALITY AND CONSTRUCTION

By Prof. Dean Peabody, Jr.,* Member, Boston Society of Civil Engineers

My colleagues will soon present to you a long array of variations of allowable stresses and improvements in design. Before they do so I should like to say a word of warning. This is that these improvements in the accuracy of design are of no avail, unless the concrete gives the strength which was assumed for design. The successive codes have the tendency to increase the allowable stresses, — that is, the fiber stress, shear, diagonal tension, and, to a certain extent, the column stresses. Such increases are not justified unless there is a corresponding improvement in the reliability and uniformity of the concrete. This improvement can best be assured by two methods, — first, by the adoption of a tried and proved method of proportioning the concrete; and second, by testing the resulting product. The present code provides for both methods and has adopted the water-cement ratio for the proportioning of the concrete. It is possible, with a little forethought on the part of the contractor by selecting his material before he starts to use it, to construct for himself the water-cement strength relation, and to make sure that he is predicting accurately in advance the strengths which he will realize. This assumes he has good sound material, and that it does not vary, and also that he has some means of testing on the job the consistency of his mix. This method of proportioning has now been tried long enough in the field, so that we can foretell results with a good degree of assurance. The slump test gives a fairly good idea of the consistency, and by grading tests you can keep track of the aggregate.

The present method of design assumes that you have previously selected, or are forced to use, certain definite aggregates. In a locality such as Boston, where many sound aggregates are available, it still leaves to the contractor the problem of what aggregates he shall use and in what proportions. That part of the problem is yet to be solved.

The second method, that of testing, is also discussed, and provides for testing the concrete as it is poured by means of cylinders. Provision is made for taking specimens out of the finished structure, and also for load tests of the finished structure.

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* Department of Applied Mechanics, Massachusetts Institute of Technology, Cambridge, Mass.

All of these methods of testing assume you have either purchased a testing machine or are sending your samples to a testing laboratory. Here, again, we have not reached the ideal. We are still far away from the simple, foolproof, cheap test which the ordinary contractor can apply on the job and assure himself that his concrete is all right. Perhaps something can be developed like the Massachusetts Highway Department's test with a cantilever beam. They cast a plain concrete beam, fasten the testing-rig to the tail end of a truck and test the concrete in the field. Perhaps something like that will yet be realized for building construction.

I am going to run over very briefly the five chapters assigned to me for discussion. They are primarily concerned with the making and placing of concrete. I have been asked to speak only on the changes which have been made in the present code as compared with the 1924 Joint Code. I want you to notice that all these changes are in the direction of ensuring greater reliability and uniformity in the product.

In chapter 1 there is a new paragraph which says that all drawings and calculations of the structure shall be available for the Building Commissioner.

Chapter 2, on Materials, provides that the Commissioner of Buildings shall be permitted to take specimens from the structure to test, and if they are not found satisfactory he may make load tests of the actual structure. He may have a load applied on any given panel equal to one and a half times the live load plus one-half the dead load. Another section provides that the architect or engineer shall be responsible for the inspection of the materials and conditions under which the work is being constructed. Record shall be kept of the periods during which the temperature is below 40° F., and of the methods of protecting the work when the temperature falls below that point. The steel has been standardized. It is proposed to use billet steel only of the intermediate grade, and to permit somewhat higher stresses than in the past.

Chapter 3, on Quality of Concrete, discusses the method of proportioning by the water-cement ratio. Two possible ways of using it are given. By one the contractor, assuming his material is average, applies the results of previous tests as given in the code to his own particular problem; and the other, the more accurate method, consists of his selecting his materials and constructing for himself the strength relation for the particular materials used on his job. The method of proportioning is described in detail with references to the proper specifications for determining the procedure. There is also an attempt to eliminate the design of freak concretes where too coarse aggregates are used, giving a harsh concrete. It is required that the aggregate must be of such proportions that the resulting concrete is workable. Again, in order to give reasonable mixes it is recommended that the sand be not less than one-third or more than two-thirds of the total aggregate.

Chapter 4 deals with Mixing and Placing of Concrete. It will suffice to read the paragraph headings to show its content. We have the removal of water, cleaning of the forms, inspection, mixing, transporting, placing and curing of the concrete, also cold weather precautions. If you follow all the instructions there given you can hardly escape a good concrete.

Chapter 5 deals with Construction. There are paragraphs covering the design and erection of forms, the cleaning, bending and placing of the reinforcing steel. You will note a tendency for increased fire protection, which has its due effect upon the amount of steel used in beams at a given depth, increasing the amount of steel, particularly the compression steel at the support.

In summing up I would like to quote from an article I saw recently in regard to the concrete used in the New York subways. The writer stated that using the same material and the same amount of cement the average strength of the concrete had been increased nearly 90 per cent in a comparatively few years. That is due merely to the fact that they have given careful attention to the selection of material, proportioning of the mix, and the mixing and placing of the concrete.

DESIGN, FLECTURAL COMPUTATIONS AND MOMENT COEFFICIENTS, SHEAR AND DIAGONAL TENSION, BOND AND ANCHORAGE

By C. Hale Sutherland,* Member, Boston Society of Civil Engineers

The utility of the many curves and tables made up in the past for reinforced concrete design suffers a serious curtailment under this tentative code through the new values assigned to n, the ratio of the moduli of steel and concrete. We have become accustomed to the use of $n=12$ for concretes with a twenty-eight-day ultimate strength (f'_c) ranging from 2,900 pounds per square inch down to any value above 2,200 pounds per square inch, with $n=15$ for weaker and $n=10$ for stronger concretes. The new code gives the formula

$$n = \frac{E_s}{1000f'_c} = \frac{30000}{f_c}$$

which gives the familiar values of 15, 12 and 10 for the strengths most commonly used, 2,000, 2,500 and 3,000 pounds per square inch, respectively. For other grades intermediate values of n result, with a consequent need for new designing charts. Whether our knowledge warrants this refinement, and whether the gains in formula simplicity offset the decreased range of the old charts and tables, are inevitable questions which one is tempted to answer in the negative.

One other matter in the sixth chapter deserves notice, — the provision for an increase of 50 per cent in the working stresses for members carrying dead, live and wind loads.

In chapter 7 appear two sets of rules not contained in the 1924 Joint Committee Report, one set relating to ribbed floor construction, summarized in Fig. 1, and the other to slabs supported on four sides. These latter regulations are a modification of those recommended by the 1916 Joint Committee, retaining their simplicity and doing away with their extreme and uneconomical conservatism. The same limitation as to ratio of spans is made and the same total load distribution, two-way reinforcement being required if the longer span (L) is less than one and one-half of the shorter (B), and the proportions of the total unit load (W) on the slab carried in the short direction being

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* Associate Professor of Structural Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

$$W_B = W(L/B - 0.5).$$

However, instead of the load curve for a supporting beam being assumed a parabola, the distribution is taken as uniform so far as the beam is concerned. "In placing the (slab) reinforcement, account may be taken of the facts that the moment is less in the portions of the band which are adjacent and parallel to the supporting beams. In the one-quarter width of band parallel and adjacent to the beams the computed moment may be reduced 50 per cent."

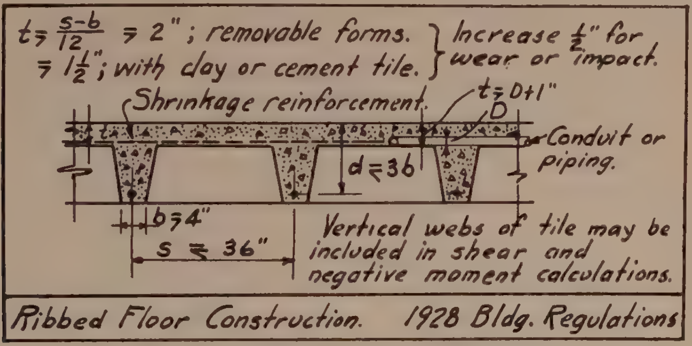
$t \geqq \frac{s-b}{12} \geqq 2''$; removable forms.
$\geqq 1\frac{1}{2}''$; with clay or cement tile.
Increase $\frac{1}{2}''$ for wear or impact.
Shrinkage reinforcement.
$t \geqq D+1''$
D
Conduit or piping.
$d \leqq 3b$
$b \geqq 4''$
$s \leqq 36''$
Vertical webs of tile may be included in shear and negative moment calculations.
Ribbed Floor Construction. 1928 Bldg. Regulations

FIG. 1. — RIBBED FLOOR CONSTRUCTION

In connection with slabs the new rules regarding bar spacing and temperature steel are of interest. The maximum spacing for the principal slab reinforcement is set at three times the thickness of the slab; shrinkage and temperature reinforcement must be used with one-way slabs, spaced not more than 18 inches, or five times the slab thickness, and in amount not less than from 0.0018 to 0.0030 for the ratio of steel area to concrete area, varying for roof and for floor slabs and for plain bars, deformed bars and wire fabric.

In Figs. 2 and 3 the attempt is made to summarize the provision of the Tentative Code relating to diagonal tension. In this chapter (8) an excellent start is made by setting a constant value of $\frac{7}{8}$ for j in all shear formulas, and a limiting value of 16,000 pounds per square inch for stress in web reinforcement. The usual formula is used for vertical stirrups. New limits are set for spacing, measured perpendicular to the stirrups or bent bar, the results of which, as compared with the 1924

Joint Committee spacing, are shown in Fig. 2. Where the web reinforcement consists of bent-up bars in a single plane the vertical component of stress in the sloping portion of the bars is taken as the shear at the section diminished by the amount carried by the concrete. This is a welcome simplification with good theoretical basis. However, the Code is not so happy in its treatment of inclined stirrups or bent-up bars in series. Here it reverts* to the somewhat archaic theory outlined in the sketch in the lower right-hand corner of Fig. 3, which asserts inclined bars to be more effective than vertical stirrups, with same horizontal spacing, in the ratio indicated by the heavy curve of Fig. 3. A brief study of the forces acting on the portions of the beam shown in the lower left-hand corner of this figure should convince one that the formula there given, plotted as a dash line in the diagram above (the 1924 Joint Committee recommendations for bars flatter than 45°), is more nearly correct. This sketch is closely that used by Prof. T. D. Mylrea in his paper, "Studies of Shear in Reinforced Concrete Beams," Proceedings,

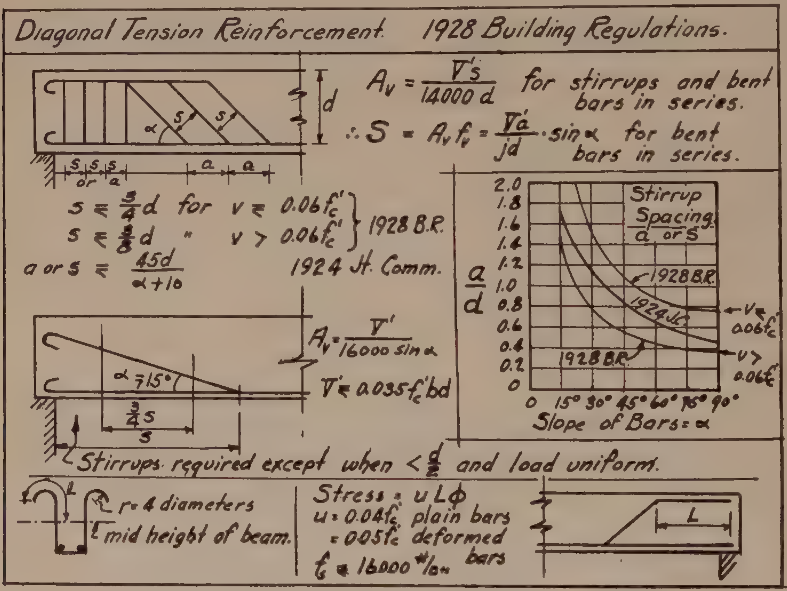
Diagonal Tension Reinforcement 1928 Building Regulations.
d
s
s
α
s s s
or a
a a
$A_v = \frac{V's}{14000\,d}$ for stirrups and bent bars in series.
$\therefore S = A_v f_v = \frac{V'a}{jd} \cdot \sin\alpha$ for bent bars in series.
$s \leqq \frac{3}{4}d$ for $v \leqq 0.06f'_c$
$s \leqq \frac{3}{8}d$ " $v > 0.06f'_c$
1928 B.R.
a or $s \leqq \frac{45d}{\alpha+10}$
1924 Jt. Comm.
$A_v = \frac{V'}{16000 \sin\alpha}$
$V' = 0.035f'_c bd$
$\alpha \overline{\gtrless} 15°$
$\frac{3}{4}s$
s
Stirrups required except when $< \frac{d}{2}$ and load uniform.
Stirrup Spacing $\frac{a}{}$ or s
$\frac{a}{d}$
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1928 B.R.
1924 J.C.
1928 B.R.
$v \leqq 0.06f'_c$
$v > 0.06f'_c$
0 15° 30° 45° 60° 75° 90°
Slope of Bars = α
r = 4 diameters
℄ mid height of beam.
Stress = $uL\phi$
$u = 0.04f'_c$ plain bars
$= 0.05f'_c$ deformed bars
$f_s = 16000$ #/□"
L

FIG. 2. — DIAGONAL TENSION REINFORCEMENT

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* This reversion is made somewhat obscurely. The same formula is used for stress in vertical stirrups and in bent bars in series, $A_v = V's$, 14000 d. Since s is measured perpendicular to the bar or stirrup this gives $A_v f_v = (V\,s/jd)\ sin\ a$ with s defined as the horizontal spacing, its usual meaning.

American Society of Civil Engineers, January, 1929. The complete derivation is given there.

Considering the uncertainties of the problem it would seem better to return to the 1916 Joint Committee ruling for bent bars, or even to use the same formula for all slopes including the vertical which is equivalent to using a lower working stress for inclined bars. The reason for such lower stress is set forth by Professor Mylrea in the paper already referred to.

Welcome simplification appears in the ninth chapter regarding bond stress and anchorage. The portentous formula (No. 35) of the 1924 Joint Committee for the stress in a bar as fixed by bond raised the limit of bond stress for anchored bars indefinitely, with no fixed limit. Fortunately, this has been here replaced with a definite maximum for anchored bars of double the usual bond value, with clear rules given as to anchorage.

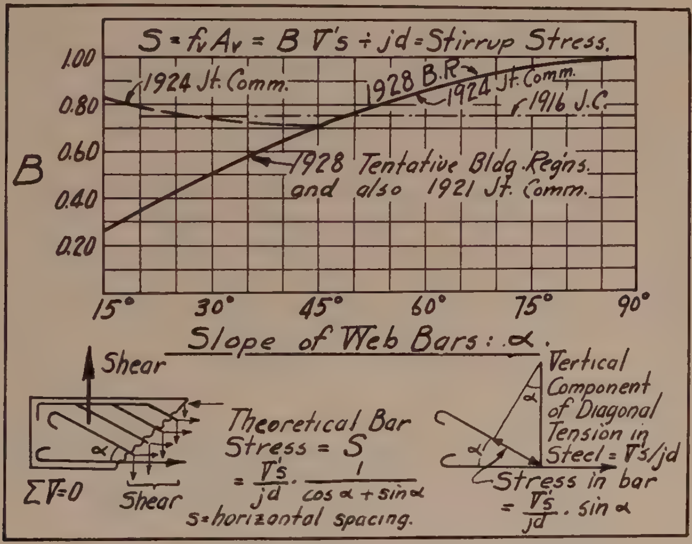

FIG. 3. — INCLINED STIRRUPS AND BENT-UP BARS

The anchorage of stirrups is made more liberal; safe working load in the steel is made to depend on the surface area of the bar embedded in the upper or lower one-half of the beam instead of a depth of $0.3d$ as in the 1924 report.

There are numerous other differences of detail between the old report and the new Tentative Code, but probably all the important ones will have been described with the inclusion of these rather random notations.

The code permits a flat bracket (less than 45°) to be counted as increasing the depth of a beam, but not as decreasing the span.

Floor finish is not permitted to be counted as a part of the structural slab unless cast monolithic. If the surface wear is unusual, the top one-half inch may not be counted on for strength.

The rules for the spacing of reinforcing bars are changed slightly and extended specifically to cover the compression reinforcement in the stems of continuous beams, the amount of which is limited to 2 per cent. Such reinforcement must be stayed with binders in the fashion of column reinforcement. If the steel arrangement makes concrete placing difficult, mortar must be poured to fill in the cramped location.

The cross reinforcement in girder flanges is required to be figured for cantilever action.

The moment of inertia of members is specified as that of the full concrete section only, without counting the steel.

Where shearing stress in any beam exceeds the limit of $0.09f'_c$ (maximum set at $0.12f'_c$ as in 1924 report) the member must be constructed under the personal supervision of the designing engineer with advance notice to the Building Commissioner of the day of pouring.

FLAT SLABS, REINFORCED CONCRETE COLUMNS AND WALLS AND FOOTINGS

By C. E. Nichols,* Member, Boston Society of Civil Engineers

The Building Code on flat slabs is essentially the same as the Joint Committee Specification, although some features have been clarified and minor changes made. No changes have been made in the moment coefficients except for wall and other panels non-continuous on one edge (paragraph 1011), where the new code provides for an increase in maximum positive moment of 25 per cent above the interior panel moment. The Joint Committee Specification called for an increase in these moments of 15 per cent for column strips and 30 per cent for middle strips, and this increase also applied to the negative moments at the first interior columns.

The new Building Code specifies definite negative moments at wall supports or discontinuous edges, while the Joint Committee was not specific on this point.

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* Structural Engineer, Stone & Webster Engineering Corporation.

Very slight changes have been made in the assumed location of points of inflection for slabs and slight changes in the arrangement of reinforcing.

A good paragraph has been added in regard to openings through flat slabs which was not covered in the Joint Committee Specification.

In the new code the strength of the concrete to be used in the structure is a factor in determining the minimum thickness of slabs.

The principal changes in the section on reinforced concrete columns and walls from the Joint Committee Specification are the increase in allowable compressive stress for columns with lateral ties from 0.2, the ultimate strength, to 0.225 times the ultimate strength, and the change in the spacing of lateral ties from 8 to 12 inches.

A protective covering of 1½ inches outside the reinforcing is now specified for spiral columns, while the Joint Committee called for 2 inches covering in round or octagonal columns, and 1½ inches covering for other columns. The area of spiral column cores is now measured to the outside of the spiral reinforcing.

The stresses and limitations for composite columns and combination columns are slightly different from the Joint Committee Specification, but these differences are insignificant.

The formula for working stress in long columns with spiral reinforcement allows a slightly higher stress, and applies to columns having a length greater than 50 times the least radius of gyration instead of 40, as in the Joint Committee Specification. The formula for long laterally tied columns, however, is unchanged.

The new code has a paragraph on reinforced concrete bearing walls, giving limitations of length, unsupported height and thicknesses, together with a table of minimum wall thicknesses. This subject was not covered in detail in the Joint Committee Specification.

The section on footings is essentially the same as in the Joint Committee Specification, except that the length of dowel rods extending into the columns or pedestals above footings is specified as not less than 30 diameters for plain bars and 24 diameters for deformed bars, while the Joint Committee Specification called for 50 and 40 diameters, respectively. New paragraphs have been added allowing higher working stresses for the transfer of column loads to the footings when spiral or hooped reinforcement is provided in the footing. This section covers a recognized practice which was not adequately covered in the Joint Committee Specification.

In general, it may be stated that the new building code is essentially the same as the Joint Committee Specification on these three subjects, but has been extended and clarified in interpretation. The only changes of importance are the increase in stresses for laterally tied columns and the addition of the section on reinforced concrete walls.

ALLOWABLE UNIT STRESSES IN CONCRETE

By Walter C. Voss,* Member, Boston Society of Civil Engineers

All of the specifications for the design of reinforced concrete are predicated upon the ultimate strength of the concrete in pounds per square inch, at the age of 28 days. This is, of course, an arbitrary guage, but carries with it a significance which you all appreciate, but which it would not be amiss to call to your attention.

Let us assume the erection of a reinforced concrete building of twelve stories, and that the frame will proceed at the speed of one story per week. Let us also assume that the building is designed for a live load of 100 pounds, and that the resultant dead load in the completed building is also 100 pounds. This represents a fairly typical case. It is, furthermore, safe to assume that the construction load will not exceed the additional dead load imposed upon the skeleton by finish materials. Before any part of this building is loaded to its full complement of live and dead load the concrete everywhere will be from 3 to 6 months old, the older concrete being in the more heavily loaded columns, as a critical case.

Let us compare section 306 of the Building Regulations with the practical facts at the building. There is not the least doubt in the mind of any engineer acquainted with the facts that the following safe general scale of increased strengths at greater ages holds. If the age at 28 days is considered as 100 per cent, the strength at 3 months is 130 per cent; at 6 months is 140 per cent; at 1 year is 150 per cent; at 2 years is 160 per cent; and at 5 years is 200 per cent. Assuming that all concrete is at least 3 months old before it commences to carry its full complement of load, it is a simple matter to compare calculated resistances with actual resistances.

Let us take 2,000-pound concrete as an example. The allowable calculated stress in the extreme fiber in compression (*fc*) is 800 pounds per square inch. The actual ultimate value of this concrete is 2,600 pounds per square inch effecting a factor of safety of 3.25. Let us examine the same concrete in shear. Any number of tests have proven that the shear due to diagonal tension in plain concrete is in the neighborhood of 10 to 15 per cent of the compressive strength. Assuming 10 per cent the ultimate shear value of this concrete at 3 months is 260 pounds per square inch. Paragraph 306 allows only 40 pounds. Here we have a factor of safety of 6.5 or double that in compression. In bond we find similarly extensive tests, pointing to a minimum average of from 15 to 20 per cent of the compressive strength as a bond stress for deformed bars at the point of .001 inch slip. The actual resistance of 3 months old concrete would be 390 pounds per square inch. Paragraph 306 allows 100 pounds per square inch. Here we have a factor of safety of 3.9.

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*Associate Professor of Building Construction, Massachusetts Institute of Technology.

As shear has been the "bone of contention" for many years, I suppose a factor of safety of 6.5 is warranted — perhaps. At any rate, the index values of $f'c$ as given in this code are far from excessive. They are conservative. For example, the value allowed for shear in beams with properly designed web reinforcement, specially designed anchorage of longitudinal steel, plus an "affidavit" is .12 $f'c$ or 240 pounds for 2,000-pound concrete. The resistance of the concrete alone is at least 1,000 pounds where diagonal tension is properly resisted, giving us a factor of safety, at least without the "affidavit," of 4.2. If the building should be 6 months old before loaded, all of these values would increase about 10 per cent. More important than all of this splitting of hairs on indices is the assurance which every engineer must have, — namely, that his fundamental strength, pounds per square inch in compression, upon which all of these factors are based, shall be there. That means an adherence to the entire code, including water control, with workable concrete. You will remember that "unworkable" concrete may be either "crackerjack" or "soup."

I want to add to this, with your permission. Perhaps no one has had an opportunity of checking up the concrete which is being placed in many localities, outside of the Testing Laboratories, to such an extent as the engineers of the Portland Cement Association.

I want to impress on you again the not unusual occurrence which was recently illustrated here in Boston in a large building which was being erected by a reputable contractor. At the end of a month some of his concrete tested 900 pounds per square inch when it was designed to be 2,000-pound concrete. It is very important that we get the strength assumed in the design.

In connection with sections 306 and 307, the factor of safety of steel is now less than 2. The factor of safety of concrete in this new Building Code is well above 2. I think this is in the right direction. We can get 5,000 and 6,000 pound concrete if we wish to pay for it. The various factors used in these two paragraphs which are applied to the compressive strength as a basis for the control of concrete are not worth the paper they are written on unless you know that the concrete on the job is going to test the 2,000 pounds on which the design is predicated. What are you going to do to make this certain? We can not do this in Boston yet, but I hope we shall soon be able to design a 1:2½:4½ concrete and call it 2,200 pounds. We must also be sure that we get it, because, if you use the percentages in this code, and the concrete does not test up this high, then you must certainly have a factor of safety of 6 per cent plus an "affidavit."

Discussion

Edward H. Cameron:* In the early stages of modern reinforced concrete construction, the efforts of engineers who were studying this comparatively new material appeared to be more largely concentrated upon the development of proper design assumptions and methods of designs than upon the theoretical control of the field mix. As time went on, it became apparent, from the point of view of economy and durability, that more attention should be given to the control of the mix.

With Professor Abram's announcement of the water-cement ratio theory, the modern conception of the steps which were necessary to follow, if economical and durable concrete were to result, was developed. For the past four or five years many jobs have been built in accordance with the methods of field control which have become familiar to all through the efforts of the Portland Cement Association and others. Considerable opposition from men versed in the old methods has been met with, but the new methods have proved to be economical, safe, and, in fact, essential, if reinforced concrete construction is to maintain its position in the field of modern industry where competition dictates more and more stringent economies in material and labor costs. This is strikingly apparent when the methods of the average construction job are compared with those of manufacturing industries.

The speaker believes that Mr. Voss hit the nail on the head when he stressed the necessity of assurance that the field men were making concrete of the 28-day strength specified, in order that the design working stresses based upon this 28-day strength could be safely used. The

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*With Jackson & Moreland, Engineers, Park Square Building, Boston, Mass.

Building Code of the American Concrete Institute appears to be a splendid set-up of the way to obtain this assurance.

The speaker recently had occasion to visit a large concrete job in which the modern methods of control are to be followed. This was the foundations for the Kill Van Kull bridge which is to span from Port Richmond, Staten Island, to Bayonne, New Jersey. The specifications for this work leave the amount of cement to be used to be determined by the resident engineer. The quantity of the coarse aggregate, in general, is to be not less than, nor more than, twice that of the fine aggregate. Twenty-five hundred pounds per square inch is specified as the 28-day strength, test specimens being required before the first concrete is placed, and from time to time during the work. All material is to be measured by weight. The water-cement ratio is based upon 6½ gallons of water per bag of cement. "The proper workability of the mix shall be obtained not by the addition of more than 6½ gallons of water per bag of cement, but rather by the reduction of the total amount of mix aggregates in each batch." One and one-half minute mixing is specified for a 1-yard mixer, and not less than two-minute mixing for larger mixers. The above notes are abstracted from the specifications for this work as prepared by the Joint Authorities of New York and New Jersey.

MR. WALLACE F. PURRINGTON:* We have had a couple of years' experience with the use of the water-cement ratio and design on the basis of 5½ gallons of water per bag of cement. We base our designs on the B curve and not on the A curve, because we figure that as fine as we may design the material, we can't carry out laboratory methods in the field. We base our design on 2,700-pound concrete, and have been running on about ten jobs a minimum of 2,600 pounds for 28 days, and a maximum of 3,100.

I just heard a speaker say it was not fair to compare laboratory specimens with what happens in the field. The results stated are for field-stored specimens, not laboratory specimens. If we get our design strength under field conditions, we feel we are safe in assuming that we would get them under laboratory conditions.

Another speaker said something about not being able to test the material because they didn't have a testing machine. I can't see why the results of a beam-testing machine aren't just exactly as good and as practical for design as compression tests. Plenty of investigators have shown that a 7-day test multiplied by 5 will give very nearly the

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* Materials Engineer, New Hampshire Highway Department, Concord, New Hampshire.

7-day compressive strength. They also show that a factor of 6 will give close enough to the 28-day test. So if we assume a factor of 5½ we are conservative, and if we get 2,700 pounds with that factor we are perfectly safe.

It may be an interesting fact to note that in most cases the average cement factor, based on the material used, was 1.45 barrels to the cubic yard for concrete. That is brought about by a judicial choice of aggregates. If we used small aggregates down to 1 inch our cement factor would be 1.60 or 1.70 barrels of cement to the cubic yard. We are fortunate in having coarse graded aggregates, and are taking advantage of this fact to turn it into dollars and cents.

In 1926 the average price for concrete per square yard, including steel reinforcement, expansion joints, etc., was $2.76 per square yard. In 1927 it was $2.29. In 1928 this price is $2.14 per square yard. The quality of the concrete is good. I can't see why we should not take advantage of the good aggregates we have and put those together to save money for the State. If we had let the 1928 contracts at 1926 prices it would have cost the State of New Hampshire just $202,000 more. Of course, it is not all a question of design, but we will take our fair share of the credit. I believe it has been a pretty good investment for our State to proportion our concrete based on an application of the water-cement ratio method.

HENRY B. ALVORD:* I have been wondering just what each individual might get from this talk that would be useful to him in his own work, and I want to ramble a bit and make one or two points, if possible.

May I suggest two somewhat opposing methods of formulating a code of concrete construction, namely, the "white collar method" and the "flannel shirt method." By "white collar method," I mean extensive mathematically derived deductions based on a paucity of test observations in the laboratory and the field. By "flannel shirt method," I refer to a thorough technique in laboratory methods resulting in intimate acquaintance with the behavior of the materials involved. Results from the latter method seem to me to be more likely to be interpreted in terms of laboratory and field precisions, rather than in the mathematical abstractions so often emphasized in the former.

The former tends to a maximum of theory with a minimum of practical experience. The latter tends to a maximum of practical experience with a minimum of theory.

Now if we consider the report from these two standpoints, we will see that certain paragraphs in the report still smatter somewhat of the

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* Professor of Civil Engineering, Northeastern University, Boston, Mass.

"white collar" point of view, yet I think great progress has been made in the last ten years in looking at this proposition from the "flannel shirt" viewpoint. It is well to lay emphasis on the proper values of working stresses, but it is more important to find out how the concrete is actually being made, to see if it is possible to increase the strength of the concrete 50 to 150 per cent. I do not see anything disastrous in raising the working stress from 32½ per cent to 40, and 37½ per cent to 45, and raising the shear in some places 100 per cent, and likewise the steel stress from 16,000 to 18,000 and 20,000. These are all good, but I think Mr. Voss has brought out the meat of this proposition, namely, that we are able, and have been for about five years, to make concrete which will conform within about 10 per cent to any strength we decide on in advance, from 2,000 up to 5,000 pounds per square inch ultimate strength.

It comes down to this. We have three or four things to work for: one is strength; another is workability; another is yield; and a fourth is sometimes called density, permanence or waterproof quality. You can't get the maximum of all of these in any one operation, but by taking proper precautions in the design of mix any desirable combinations of these items can be maintained. By this method, as the last speaker has said, we can get a vast increase in economy, with corresponding saving in the cost of construction.

In closing, I would like to say, and I feel sure that the Portland Cement Association can give many instances to illustrate this statement, that for some years now the larger companies doing reinforced concrete construction work have been dealing with their clients in such a way that wherever the authorities of the cities permit, the building company has taken over the guaranty of the strength of the concrete. No rigid proportioning, such as 1:2:4 or 1:2½:5, etc., has been required in advance, but the owner said to the contractor, "You make the concrete as you see fit. We have confidence in your judgment. Of course, our engineers and inspectors will co-operate with you and check your work as it progresses." These companies have been leading the way and showing the way for the rest of us.

Mr. Hersum:* The permissible bond stress has apparently been changed from that in the 1924 Joint Committee Specifications. With anchored ends, bond was unlimited. Now the limit is given as double the usual values where special anchorage is provided. I do not know whether there is a reason for this change, but perhaps Professor Sutherland can tell us.

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*52 Garden Court, Cambridge.

PROFESSOR SUTHERLAND: My interpretation of the 1924 document has always been like Mr. Hersum's, — that with anchored bars, there was no limit placed on bond stress. However, I understand that the members of the Joint Committee consider that a strict adherence to their formulas and specifications will keep bond stresses down to about the limit set definitely in the 1928 Tentative Code. If this is correct, it explains the point.

MR. HERSUM: The idea of having inverted stirrups near the supports of a continuous beam is a very good one, since these take care of any reversal of the shear distribution. Another question on vertical stirrups and bent-up bars is why the bonding of the stirrups into the concrete is assumed to be from the hooked ends to the neutral axis, and only along the horizontal portion of the bent-up bars in the top of the beams. This seems to me to be rather hard on the bent-up bars.

PROFESSOR SUTHERLAND: Presumably the point the Committee has in mind is that diagonal tension stress may exist in the upper portion of the sloping bar, since in continuous beams the diagonal tension cracks come in the top.

MR. HERSUM: In paragraph 504, on Placing Reinforcement, in the American Concrete Institute Specifications, are we to infer that spliced bars are to be spaced at a minimum distance of 2½ diameters for round bars, and three times the side width for square bars?

PROFESSOR SUTHERLAND: The rule in paragraph 505a so states, but the meaning is not absolutely clear. My interpretation would be that the clear spacing requirements of paragraph 504 must be met at the splice, which would result in greater spacing elsewhere. The stringent rules laid down in paragraph 706d, relative to the spacing of compressive reinforcement at the supports of continuous beams, would tend to support this view.

MR. NICHOLS: Mr. Hersum apparently refers to the case where the minimum spacing of bars in a beam applies to bars spliced over a support. In other words, bars coming into a column from the bottoms of beams on both sides, if counted on for compression steel, must have the distance apart specified for bars in other locations in beams.

MR. HERSUM: Does that apply to the spacing of bars, too?

MR. NICHOLS: I don't know that it is specifically mentioned in the code or in the Joint Committee's report, but I consider that it should apply to all spliced bars. However, in a good many specifications and codes it has been required that mechanical splicing be furnished, or that the bars be kept sufficiently apart so that the concrete will develop full stress in bond.

Mr. E. W. Roemer:* I am very pleased to speak here tonight. My early education in concrete construction was all in the field, and I was brought up to believe that the designers gave no consideration whatever to the men who were building the buildings. I am very glad to learn tonight I was in error.

As you all know, in Boston today we have a Building Commissioner who is extremely progressive, and he looks with favor on everything that is in the line of progress, providing it is not detrimental to the safety of the building. The reaction I got here tonight from the talk on increased stresses in the concrete and the reinforcing steel was that it might be all right for the regular contractor, a man who studies the theory of building construction, but we have a great many contractors who know nothing of the theory, and concrete to them is a mixture of cement, sand, stone and water, and that is all that they know or care.

In listening tonight I thought of a test recently conducted by the Building Department, on a roof designed for a live load of 40 pounds and was loaded to 200 pounds per square foot, with a deflection of less than half an inch, and a full recovery in about three hours after the test load was removed. On that roof we had an unnecessarily large factor of safety. Compare that with another roof I know of that was designed properly, poured the first part of December, a letter written to the contractor ordering him not to remove supports on the twenty-fourth day of December. The supports were removed without orders during March and the roof fell in. How, if we decrease our factor of safety, are we going to make provision for that sort of contractor?

In Boston, as you know, we have allowed some engineers, that are satisfactory to the Building Commissioner, who are designing structures or buildings, to sign an affidavit that their buildings are designed according to the law. Our present Commissioner has accepted those affidavits on condition that the engineers also file a certificate on completion of the work, stating that the building is constructed according to the plans and according to the law. I think that is one of the greatest steps we have made in Boston toward getting good construction.

It may be news to some here to learn that the building law of Boston is the only law in the country that is an act of Legislature. The opinions of the officials of the Boston Building Department have little or no effect on what might be accepted as law if such a code as has been discussed here tonight were accepted for Boston. It would only be done as an act of Legislature.

Mr. Voss: I do not often get an opportunity to say publicly for

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* Supervisor of Construction, Boston Building Department.

Mr. Roemer what I think of his fairness in connection with code enforcement.

I remember in one particular case where I think Mr. Roemer and every one else connected with the building department was willing to move heaven and earth to allow the job to go through on water-cement ratio lines. But it had to be turned down on the letter of the law. I don't know whether I am now treading on dangerous ground, but I feel that our Boston code might be vigorously revised.

I think the city of Boston is a little more closely in touch with these matters than some cities, with the intention of being civically helpful. The Legislature here has to determine what Mr. Roemer enforces in the City Hall, and sometimes the legislative committee does not know much about bond stresses, the cement ratio, and so on. If an opportunity does come up in the future to change our code in Boston I think you fellows ought to turn out *en masse*, and by force of numbers and sentiment put over such changes as are necessary and much belated.

MR. NICHOLS: Mr. Roemer has very graciously let me get a few remarks in here which I hesitated to say earlier.

There are a lot of contractors, even today, who think that concrete is just "mud," and we must legislate them out of the privilege of doing business, and make it difficult for them to carry on here in Boston unless they conform to the laws which will prevent endangering the lives of people and damage to property. At the same time, such legislation should give to the contractor who thinks in other terms than "mud" an opportunity to work economically. Some of you, perhaps, don't realize that in 1922, when the idea of the contractor practically guaranteeing the quality of his concrete was first suggested, the best contractors in the country — those nationally known — arose in holy horror. They said it was absolutely out of the question, and undertook to demonstrate that it couldn't be done. They financed the series of tests conducted under the auspices of the Joint Committee, and that is what made of them present-day contractors. They spent good money to prove that the "white collar" engineers were just full of notions, and they succeeded, instead, in convincing themselves that even if they did wear "flannel shirts" they could still learn a lot about concrete. That is why the contractors who first opposed the idea of control are going out today and begging building departments for the privilege of doing it. Of course, we have to watch the contractors who still make "mud," and we must still keep teeth in the Building Code in the city of Boston and other cities, where we have some contractors who are still "mud slingers."

E. F. Rockwood:* About a year ago I attended a meeting of the American Concrete Institute in Philadelphia where this code was discussed, and I also attended their convention this year at Detroit. I hoped that some of the matters in this code, which at Philadelphia were referred back to the Committee for further consideration, would be brought up at the Detroit meeting, and when I saw nothing on the program about it, and asked Mr. McMillan when we might expect another report, he told me that it was intended by the Committee to present the report in final form at next year's convention.

I was interested in the points brought out tonight, especially along the lines mentioned by Professor Voss and Mr. Cameron, *i.e.*, how to get the strength you desire from your concrete. I heard a paper at the Detroit Convention read by a representative of the Detroit Edison Company, in which he said that his company had been obliged to get away from the idea of specifying 2,000-pound concrete because they found that their men could get 2,000-pound concrete with such a small amount of cement that it was not durable, and therefore they had to establish a minimum amount of cement that could be used.

I also heard a paper in which were reports of tests made by the Building Commissioner of the city of Detroit. During the last four or five years he had cylinder tests made on every job, and on the same cards on which the results of these tests were reported, was given, for comparison, the strength of the concrete called for on the plans and specifications. I was interested to note that for two or three years they have had one or two tests per year that ran up to 6,500 and even 7,000 pounds per square inch, and that the majority of tests averaged nearer 3,000 than they did 2,000. I believe we could get such strengths in Boston, and should be allowed to take advantage of them in our design.

I have looked through the proposed Building Code and tried to recall the discussion that came up on it at Philadelphia last year. About the only things, I think, deserving serious criticism are, first, paragraph 303, on Field Tests of Concrete. It provides for test cylinders to be made on the job for various water-cement ratios, these cylinders to be made previous to actual construction. Then, during the progress of the job, additional tests are to be made of the concrete as it is being poured. If these latter tests, which are to be stored in the field under the same conditions as the concrete in the building, do not give, at 28 days, the strength which that concrete is supposed to have, the

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* 101 Tremont Street, Boston, Mass.

Building Commissioner may have the right to order a change in the water-cement ratio. I do not think that this is fair, because we all know that concrete stored under job conditions in winter weather will not have the same strength at 28 days as that stored under laboratory conditions. The object of these tests is not to determine what is the strength of the concrete at 28 days, but rather whether the concrete as mixed on the job is as strong as that which was tested in making the water-cement ratio curves, and the water-cement ratio or proportions of the mix should not be changed unless it is shown that they are at fault rather than the conditions under which these test specimens are stored. My second criticism is of the requirements for fireproofing. If they were enforced in Boston we would have to add one-half inch to the thickness of all our slabs, and approximately one-half inch to one inch of fireproofing to our beams and columns, and in addition we would have to use some sort of mesh reinforcement to hold this additional concrete in place in case of a fire. This reinforcement would be in addition to the reinforcement required for strength. If we had to do that in Boston it would be a pretty bad blow to reinforced concrete construction in Boston.

Another thing that I think should be considered is the use of concrete mixed at some central mixing plant. It was reported at the Detroit Convention that in some cases samples were taken of concrete at the central mixing plant, and then, after this concrete had been transported several miles to a job, other samples were taken of the same mix. These samples were made into the cylinders and tested at 28 days, and there was very little difference in strength between them. I do not know whether the proposed code allows concrete to be made at a central mixing plant or not.

When the last Boston code was written, in 1918, I happened to be on the committee that helped to write it. It is true that the Boston Building Committee had to be approved by the Massachusetts Legislature, but our experience in 1918 was that when we went to the Legislature, with the backing of the Boston Building Department, Boston Society of Civil Engineers, Boston Society of Architects and the Master Builders Association, nobody appeared in opposition, and the Legislature passed the code without question. I believe if we go to the Legislature a year from now with a new code on which we have all agreed, and which has the support of the Boston Building Department, Boston Society of Civil Engineers, Boston Society of Architects and the Master Builders Association, there will be no trouble in having it passed.

MAURICE A. REIDY:* Several of the previous speakers made reference to the "white collar" and "flannel shirt" men in their relation to concrete structures.

It is presumed that the engineers and the executives of the work are the "white collar" element, and labor on the job as the "flannel shirt" element.

I believe that most engineers agree on the effectiveness of proper methods for securing good concrete, and most of them are in favor of any progressive measures that will help to produce better materials of construction. It can also be said that the efforts of the Portland Cement Association and other allied interests are appreciated for the good work they have been doing along research and educational lines.

The theory of Reinforced Concrete Design is pretty well definitely established. The fundamental basis of the design, however, is predicated on the strengths of the concrete and steel and their relation to each other. The most careful and skillful design can be considerably depreciated by indifferent or ineffective workmanship. It is right here that the "flannel shirt" or labor phase enters strongly into the situation.

Unfortunately, in the field the idea seems to prevail in many cases that concrete is still so much "mud" that must be poured into a given space. Fortunately, the material is one which is very rugged, and does stand lots of abuse without apparent weakness.

There is also another phase of the field work that should be mentioned, and that is the placing of the reinforcement. It is quite common around Boston for the general contractors to sublet the placing of the reinforcement under subcontracts. Some of the subcontractors do good work, while others are not so good. It might appear at first that this condition is a favorable one, due to the fact that the work is being done by specialists, and therefore they, in all probability, do better work than those not so expert. However, it frequently happens on many jobs that when the reinforcement is placed and tied together ready for concrete, the subcontractor takes his men off the job and sends them elsewhere. In the meantime the electricians, plumbers, etc., follow along installing their work, and the job is rare, indeed, where considerable of the reinforcement has not been misplaced or kicked around to make way for these other trades. When they have installed their work the contractor is ready to pour concrete.

The reinforcement may or may not be replaced to its proper location, depending on whether or not there are any reinforcement men on the job. It often happens that there are no such men available, and it is, therefore, necessary for the superintendent to send for these men or try to have someone else do it. If he uses other trades this may lead to trouble, on account of labor union difficulties. It can be seen, then, that the superintendent and general contractor have not quite the control over their work that they should have.

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* Consulting Engineer, 44 School Street, Boston, Mass.

It must be remembered, also, that the general contractor is all set to pour concrete, and unless there is an inspector who will insist on having the reinforcement properly secured, it is questionable as to whether or not the superintendent will hold back the pouring of concrete on his own initiative. I have seen many jobs where this "initiative" was entirely lacking, and there is a large amount of work done without any inspection whatsoever by the engineer who designs the work. It might be said that the jobs that have such inspection are very much in the minority. Owners and architects do not seem to be inclined to pay for such services.

This all has a bearing on the particular subject of this meeting, — the Building Code for Reinforced Concrete Buildings. A building law or code must by its very nature take into consideration the fact that the work will be done by all classes of contractors and workmen. It does, unfortunately, penalize good organizations for the "sins" of the inferior kind. The stresses proposed are undoubtedly reasonably safe for work performed with proper control, but for the general field it is my opinion that whatever "factors of safety" the present stresses may give should be maintained. One of the previous speakers this evening emphasized the increasing strength of concrete with age, and its merits in providing rather large factors of safety. The theory of flexure in reinforced concrete design is based on the depth as an important function. The question can be reasonably asked, What happens to the factors of safety after the reinforcement in shallow beams or slabs is misplaced an inch or two from where it should be? The important factor "*d*" is subject, then, to some consideration not contemplated in the code.

As a practicing engineer, it is my belief that we need all the safety that the materials can give us, and many times on the job, some of the work I have seen, I fervently hoped that it did contain something as a factor of safety. I see nothing in the art of making concrete for the average job in this district that justifies our using any higher stresses than are now used; or, to put it in another way, reducing any factor of safety that we may now have.

The thought has occurred to me, although this may not be the proper place to express it, that the Portland Cement Association might have a very profitable field if they would spend some of their time, energy and money demonstrating to labor the merits of producing a material that is something more than "mud," and a better understanding of the importance of the reinforcement than now prevails. The education of labor is a field which I believe the cement industries can very profitably cultivate. An improved product would go a long way to eliminate honest doubt by engineers as to the safety of the structures designed by them, based on higher stresses.

Mr. Voss: My experience with the Portland Cement Association is still fresh in my mind, and my admiration for it is still more fresh. While out on the road for the Association I have been all but "kicked off a job" by the superintendent. As a superintendent myself in some of my earlier days, I was very much averse to having any one talk with my men. A good superintendent never talks directly with his workmen. He talks to his foremen. But I think it would be a good thing if some of these men could be "corralled" and talked to about concrete.

I remember particularly a job in Greater Boston, — a very fine contractor and very fine engineer. The contractor had laid a granolithic floor from which you could scrape the surface with the sole of your shoe. They had used another brand of cement in another place, and it worked satisfactorily. The entire building was built of the first cement, but where the granolithic finish went on, it didn't work. The foreman, who was an Italian, listened to me, and when I said, "You have steel-troweled too much and you haven't kept your concrete warm," he replied, "I have placed concrete for forty-five years; you can't tell me anything about it." I said, "I am not trying to tell you about the concrete. I will demonstrate. You give me the same cement you used, the same sand, one of your steel floats and a wooden float and I will put down a 10-foot square and will surface it so you can't scrape the surface off." And I did it; and incidentally stayed until 2 o'clock in the morning to do it, as the temperature in the room was about 45 to 50° F.

Here is the point, and I am glad to get this "shot at the contractor." The contractor is not in business for his health, neither is the engineer, neither is the building department, neither is the Portland Cement Association, neither is the testing engineer and neither is the client. They all have a say as to whether or not the job is going to be permanent, and whether the Association is going to be able to assist. This is the crux of the whole situation. Do we want a good job, or are we trying to swing a job to put money in our pockets?

There are a great number of contractors who are hopelessly bidding against the "mud slinging" contractor, and when he gets the job he is going to get away with everything he can. I would like to see the contractor that would not, on a "cut-throat" price. You can not talk to the workmen, but you can talk to the foremen. But look out for the subcontractor. It is up to the engineers to get around to the job for their 6 per cent, and see that the steel is in the right place and that it is tied. You will chase the steel all over the United States and ride flat cars to see that it gets there, but you will not see that it gets into the concrete, so that all your precise calculations may mean something.

The Association has spent thousands of dollars to get fellows together, and the only ones they have succeeded in getting together are you engineers and the farmers who are building cesspools and what not. If you will get the men together, the Association will furnish you half a dozen engineers to show them how to mix concrete. My answer to the whole situation is, control your strength by whatever method you want, — which is the water-cement ratio for me, — and give Tony on the job a little chance to do what he would like to do and you won't have any trouble.

As a consulting engineer on the job you are responsible for the placing of that reinforcement. You sign an affidavit, perhaps. Doesn't it mean anything? If I sign an affidavit as a consulting engineer, that the steel is properly designed and detailed, and the building falls down and kills 20 people, would I go to jail? Lawyers put their mistakes in jail. The doctors put them in graves. The engineers pay up to their full commission, but the contractor has got to pay all and guarantee his work. Do you blame him entirely for the laxities in construction? It is quality we want all the way through. Vigilance on your part as engineers, on the part of the architect, on the part of the building department, and adherence to the recommendations of the Building Code are necessary adjuncts to safe, good construction. In addition, the owner must not ask his taxi driver "to get him to the station in two minutes" and also guarantee he will get there without being dead.

MR. FRANK WHITECROSS:* From the point of view of enthusiasm, and also from the point of view of design, and being heart and soul in engineering because I like it, I should like to add a few remarks on this subject of concrete.

In 1917 I had a job on the Germanic Museum in Cambridge. We thought we were getting an exceedingly good concrete. We stayed right with it. It was being built by Simpson Brothers, one of the leading contractors at that time, well known in concrete. They worked as hard at it as I did, who was representing Harvard College at that time. We had a lot of barrel-arch ceilings to be tooled, Columns 1:1:2, etc. We did our level best to get the best grade concrete, and I think we have yet to see as perfect concrete structures as those of steel. We are still laboring for the best. We came to tool that concrete to bring out the different textures of the concrete, and when we tooled we had something like an 8-pound gun. Waples, who did the work, was supposed to be the best contractor for that. I was representing Harvard through J. R. Worcester, and trying to live up to the tradition of their inspection work, and I worked hard to have no criticism from my point of view. We put the 8-pound gun on and it rebounded so that the men almost went down through the floor, and the concrete wasn't so old but what we thought it time to tool it. But we could not tool it to bring out the different textures of the aggregate. It was red in some places, granite colored in another. So they got a 12-pound gun and used that on a 6-inch barrel-arch ceiling with 30-foot radius. And we went through it and I stood in consternation and looked at it, and I said, "I guess we weren't getting what we thought we had." We had to patch up that ceiling; do some dentistry on it. The holes were not so enormous, but it shows that the density of the mix is hard to get, and I don't think we always get it, even under close inspection. The columns had to be surfaced, and we used 1:1:2. The Burgess Company of New Jersey did it. They went up against it and charged it like a wild bull. I was pleased at the result. It was good concrete, and we couldn't make an impression on the columns. The only place was on the barrel arches. You can't give close inspection to every square inch of the job. You must have a margin of safety to work on, and I beg for that factor of safety to remain. We are glad to see you go even higher. You may say that taking steel out of a job is putting it into the concrete industry, and they will sell you steel and not give you the design that they will get from some engineers. I agree with Mr. Reidy and others, that the factor of safety should be included. It gives the occupants a better chance of safety. We have heard of concrete collapsing. Sometimes I am skeptical about building concrete in freezing weather. Anti-freezing compounds have their limitations. I believe in the safety factor, because there is that commercial engineer always on the market and the young man just out of college who is starting in for himself. I believe in a high standard being upheld all the time. I have labored hard for a high standard, and if I get one of these books in my possession in the building department, I will see that its recommendations are carried out to the letter of the law.

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* Boston Building Department, City Hall, Boston, Mass.

MILES N. CLAIR* (by letter): The Reinforced Concrete Building Regulations or Joint Code proposed by the American Concrete Institute are, as stated in the introduction, to be used as a part only of a general building code, and it is probable, for that reason, that the question of materials other than standard Portland cement and concrete aggregates, such as natural sands, rocks, crushed rock, and blast furnace slag, is not considered, and assumed as taken care of elsewhere.

There is a large field for special aggregates which the definitions given in the code do not cover. These aggregates are having and will continue to have an increasing application in structural concrete work. It seems desirable, therefore, that a code dealing with reinforced Concrete Building Regulations should give some attention to such materials.

The light-weight aggregates range in characteristics from those of burnt clay, or Haydite aggregate — which gives strengths comparable with those obtained from natural sands and gravels or rock, while the weight of the concrete is not more than two-thirds of the corresponding weight of the stone concrete — to all-cinder concrete with strengths that vary from 30 to 60 per cent of the corresponding sand and gravel concrete, and a weight less than two-thirds. In between these are numerous materials, such as Lytag, or sintered clay, oyster shells, coke breeze, granulated clay and sand-cinder combinations, with varying strengths and unit weights. The sand-cinder concrete, which is usually known as cinder concrete, has a strength ranging from 40 to 75 per cent of that of stone concrete, and a weight equal to three-quarters of that of stone concrete.

The mixing and placing of such materials require a somewhat different procedure from that of ordinary concrete because of the generally harsh working characteristics. More attention is necessary to keep the mixture at a workable consistency which will not allow the water and cement to readily separate from the aggregate.

Early high strength cements are not considered in the code, which defines concrete as a mixture using Portland cement, and defines Portland cement in accordance with the standard specifications of the A. S. T. M. The present standard A. S. T. M. specifications recognize only one standard Portland cement. Early high strength cements are of value for certain conditions, one being used in increasing quantities. The strength obtained within the first few days is of vital importance and not the 28-day strength.

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* Vice-President, The Thompson & Lichtner Company, Boston, Mass.

Suitable paragraphs could readily be inserted in chapters 1 to 4 of the code to recognize and act as a guide in the use of the special materials. The required strength of the concrete for the age at which it is to be used should be an alternate basis for determining concrete quality as specified under paragraph 301. The second method of determining quality, as specified under paragraph 303, by tests of concrete for the particular materials should be made mandatory where special materials are used.

SOME EXAMPLES OF POLLUTION OF STREAMS BY INDUSTRIAL WASTES

By Robert Spurr Weston,* Member, Boston Society of Civil Engineers

(Presented at a meeting of the Sanitary Section, Boston Society of Civil Engineers, March 6, 1929)

The growingly important subject of stream pollution by industrial waste is the matter to which this short paper contributes and regarding which so few data have been published.

So far most of the cases of stream pollution by industrial waste have occurred in the north. One naturally has in mind the pollution by sulfite pulp liquor in Maine, New York and Wisconsin; by wool-scouring waste from the Merrimack to the Delaware; by paper mill waste in such rivers as the Kennebec, the Neponset, the Nashua, the Hudson and the Connecticut; by packing-house waste, as at Chicago; by mixed textile mill waste as in Rhode Island and other states; by acid metal wastes (pickling liquors) from the metal industries, as exemplified by the Naugatuck in Connecticut, the Mahoning in Ohio, and various streams in Pennsylvania; by coal-mining wastes; by mine waste in the Pittsburgh coal-mining districts; by phenolic wastes from coke ovens and gas works; by the offensive waste from tanneries in Massachusetts, Pennsylvania, Wisconsin and other states; by waste from silk mills on the Passaic; and in addition, the starchy-saccharine wastes from glucose works, the highly organic waste from tanneries, the acid, albuminoid wastes from creameries and sugar factories, and the frequently highly corrosive and poisonous discharges from chemical works.

While the problems first appeared in the North, they are becoming important even in the South and West. Only last April the writer, representing a southern bleachery, took part in a conference between the North Carolina State Board of Health and various manufacturers in that state. At this conference it was realized that while the danger threatened rather than existed, it was good policy to anticipate and avoid bad conditions rather than remedy them. To this end, the method of co-operation is being used rather than police power. This method of co-operation has given excellent results in various states, notably in Pennsylvania and in the Ohio River Valley.

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* Of Weston & Sampson, 14 Beacon Street, Boston, Mass.

STANDARDS OF PURITY

Most standards of purity have to do with ordinary city sewage, which is largely domestic in character. With regard to pollution of streams, the legal standard established by such drastic rulings as the ones by the Massachusetts Supreme Court,* which go to the limit in protecting the rights of the lower riparian owner against the encroachment of upstream riparian owners, would, if carried to their logical limits, seriously affect industry without corresponding gain to public health and convenience.

LITERATURE

Most publications regarding pollution of streams have to do with discharges of domestic rather than industrial sewage. There are some exceptions.†

Some of the public health engineering writers, like Mr. J. A. Newlands‡ of Hartford, point out that industrial waste investigations have nowhere kept pace with the constantly increasing diversity of wastes produced, and as a general rule, the problem of pollution by industrial sewage has either been ignored or treated superficially.

An excellent contribution was made by Committee No. 6 of the American Water Works Association in its progress report on Agencies for the Control of Pollution by Industrial Wastes.§

In this, the subject of industrial waste pollution is treated broadly. The report is devoted largely to a description of the sanitary authorities, both state and federal, also those of foreign governments, having to do with pollution by industrial wastes, and to descriptions of conferences on industrial waste pollution and of legislation proposed for remedying objectionable conditions.

LEGISLATION

The status of legislation leaves much to be desired. Legislation is needed in some states to control intrastate pollution, while national legislation and interstate agreements are needed to control pollution of interstate and coastal wastes. Data on which legislation might be based are scanty, and a broad statement of the needs and of the accomplishments desired is frequently impracticable for this reason.

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* Parker *v.* American Woolen Co., 195 Mass., 591.

† See bibliography at end of paper.

‡ Stream Pollution and Industrial Wastes, J. A. Newlands, Connecticut Society of Civil Engineers' Transactions, 1926, pp. 52–67.

§ Journal of American Water Works Association, 11, pp. 628–648.

Again, the standards which the Isaak Walton League would establish, while desirable from a nature lover's standpoint, are not attainable in many cases.

As a reaction from these extreme positions, there has arisen official recognition of certain limits of tolerance. The resolution of the Sanitary Water Board of Pennsylvania, adopted August 8, 1923, classifying the streams of the state, is a good example of the modern tendency.

This resolution recognizes three classes of streams, namely, A, B, and C, and as they have been described at a previous meeting of this Section by Mr. W. L. Stevenson, Chief Engineer, Department of Health of Pennsylvania, and Secretary of the Sanitary Water Board, they are too familiar for repetition in this paper. In the words of Mr. Stevenson:

> This resolution of August 8, 1923, "recognizes that, due to existing intense industrial development on certain watersheds, the streams thereof have become so polluted that they are now totally unfit for use as sources of public water supply, nor will they support fish life, and hence are practically set aside for the disposal of industrial wastes. The cost of construction and maintenance of works for the abatement of the pollution of such streams will far exceed the value of the benefits to be derived by the public through their restoration to a clean condition," and that " . . . the natural powers of streams to inoffensively assimilate a certain amount of polluting matter, and . . . the use of the scientific method of disposal by dilution, is essential to the success of any program for stream control because of the economics of the problem."

No one has stated the present problem better than has Mr. C. M. Baker,* who realizes how futile is the attempt to maintain all streams in their natural state of purity and at the same time care for the population and industries which are dependent upon the use of some of them.

Fuller and McClintock,† in their recent book, emphasize the importance of regional control and the necessity for a broad view of the whole problem of pollution, not only from an engineering, but also from an economic standpoint.

Interesting reviews have been made by Mr. Harrison P. Eddy‡ and Mr. William Gore.§

It must be realized, therefore, by all those who investigate carefully, that the problems incident to an increasing concentration of population, particularly along rivers, are becoming more and more

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[*] "Is Stream Pollution Necessary?" C. M. Baker, Proceedings, Engineering Society of Wisconsin, 17th Annual Report, pp. 77–85.

[†] Some Sewage Problems, McGraw-Hill Book Company, 1926.

[‡] "Some Viewpoints on Stream Pollution," H. P. Eddy, Canadian Engineer, 50, 223.

[§] Discussion of Mr. Eddy's paper, *Ibid.*, 50, 226.

important, and that while absolute prohibition of pollution would, if enforced, result in hardships to industry, adequate control of streams is not only justifiable but necessary.

Investigations of industrial pollution have been hindered by lack of funds. Most of the appropriations have been devoted to matters affecting public health rather than public convenience, recreation and the conservation of fish life.

Experience shows that each stream is best considered as a unit, and the problem of the individual stream should be worked out to the greatest benefit to all interested parties. This method is far better than to consider each case of pollution by itself. This is evident when it is realized, as was shown in the studies of the Ohio River by the United States Public Health Service,* that while a stream may purify itself in its course when receiving pollution from one source in as short a time as 100 hours, the contrary may be true when insufficient time is afforded for its natural purification before the stream receives another polluting discharge.

It is a mark of progress that states like Massachusetts and Ohio, as well as countries like England and Germany, have recognized this principle of regional river regulation for particular streams by special legislation. The establishment of the Mahoning Valley District in Ohio shows the recent trend in legislation.

That control is frequently necessary is exemplified by the following results of analyses of samples of water collected from a point above and at several points below an industrial city, discharging large volumes of waste from the manufacture of paper and wood pulp into a stream which at the time of sampling had a discharge of about 2,100 second feet, and which is unusually well controlled by storage reservoirs.

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* Public Health Bulletin, No. 143.

TABLE I. — SHOWING EFFECT OF POLLUTION BY WASTES FROM PAPER INDUSTRY (P. P. M.)

Determination	Distance from Point of Pollution (Miles)			
	0.0	7.3	29.2	50.2
Turbidity	3.	35.	20.	40.
Color	35.	45.	50.	55.
Oxygen consumed	68.	114.	107.	93.
Nitrogen as free ammonia	0.070	0.136	0.124	0.036
Nitrogen as albuminoid ammonia	0.178	0.804	0.592	0.284
Chlorine	3.	7.	4.	5.
Alkalinity	13.	9.	12.	10.
Total residue on evaporation	45.	220.	205.	185.
Mineral residue on evaporation	30.	85.	75.	60.

This is not an unusual case, as experience in Wisconsin, New York, Canada and New England has shown.

Many of these mills employ the so-called sulfite process, the waste from which is a tarry, antiseptic, ligneous, sulfurous and acid liquid, which constitutes one of the worst pollutions known, and one greatly feared by all operators of water purification plants. The plant at Watertown, New York, has experienced a great deal of difficulty in treating water polluted with this waste, and has overcome it by subjecting the raw water to a long period of coagulation before filtration. The concentration of pollution at Watertown, however, is not so great as that given in Table I. Extended experiments by the writer's firm showed that the latter water could be purified only by storage for weeks before coagulation and filtration, to provide time for the sulfite liquor to decompose by bacterial action.

METHODS OF CONTROL

While state and government departments undoubtedly have many results of analyses upon which their published judgments have been based, few results are available for the public.

One of the exceptions is the report of the Rhode Island Board of Purification of Waters.* This report contains the results of investigations of the Seekonk, Blackstone, Moshassuck, Pocasset, Pawtuxet, West and Pawcatuck Rivers, which are well-known industrial streams. Many of these are in a bad condition, especially during the low-water period, and a determined effort is being made to reduce the degree of pollution in them.

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* Report for the years 1923 and 1924.

The following are offered from experience to illustrate a slightly and a grossly polluted river, and the seasonal changes which their waters undergo.

The first is the Sudbury River in Massachusetts, the upper reaches of which constituted the old Boston Water Works. There is an area of 74.66 square miles above the lowest dam of the water works, and a total of 143.9 square miles at a point six miles downstream therefrom. The reservoirs not now in use receive some slight pollution from several villages in which are located a small mill and a plant for the manufacture of aniline colors. Below the dam, the river flows through a residential and farming section, to join another river about 12.5 miles below, receiving, at a point about three miles below the dam, the wastes from a carpet mill. These consist of wool-scouring and dyehouse sewage; near the mill there discharges a brook receiving the effluent from two sewage treatment works caring for about 40,000 people.

The following diagrams, Figs. 1 to 3, indicate how this stream handled itself during each of four periods, having mean discharges of 3.47, 23.55, 1.50 and 28.9 million gallons a day,* respectively. The total period of examination was about four months.

The first of these diagrams, Fig. 1, shows the changes in color of the water. The first most noticeable effect is that of storage in the reservoir which greatly reduces the color. There is some increase in passing through the town below, and then a gradual removal of color as the stream progresses on its course, excepting during the second period, when heavy rains washed in a solution of peaty matter from the meadows bordering the lower part of the stream.

The chlorine, Fig. 2, which is a measure of the chlorides contributed to the water, shows a marked increase above the lower reservoir, due to discharges from the aniline plant. Dilution overcomes this in great measure, but below the point of discharge of sewage effluent there is another increase which in turn is largely overcome by dilution as the stream goes on its way to its mouth.

The dissolved oxygen, Fig. 3, which is an important measure of the sanitary condition of the stream, shows little change, and the most

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* Equivalent to 0.046, 0.335, 0.020 and 0.386 million gallons per square mile.

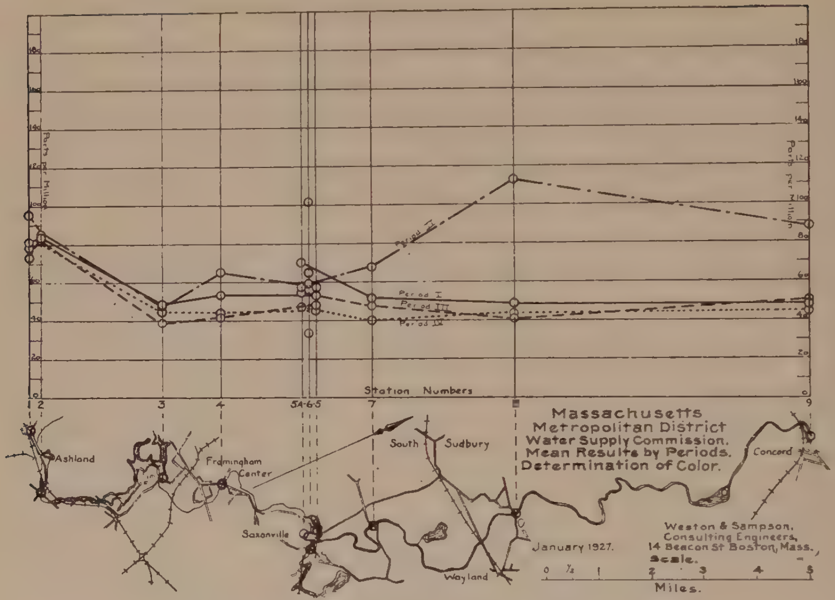

FIG. 1. — SUDBURY RIVER — CHANGES IN COLOR

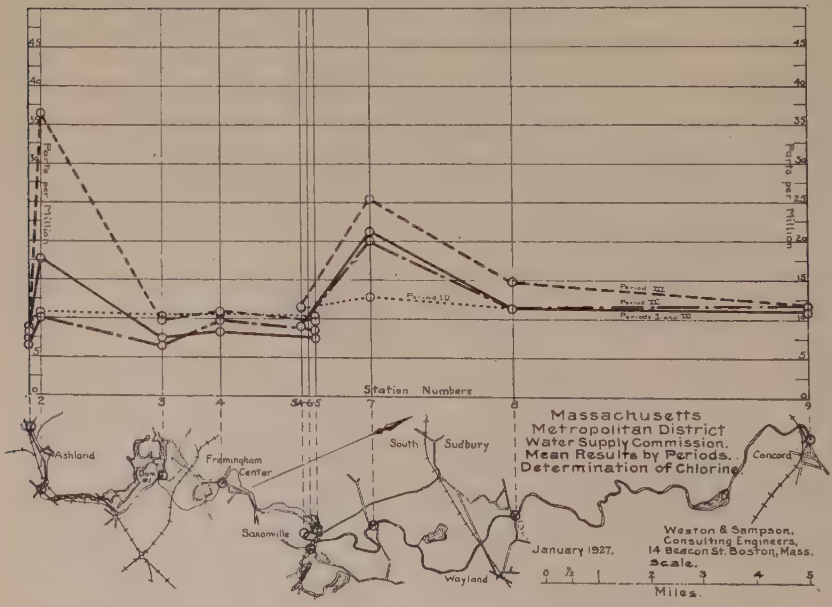

FIG. 2. — SUDBURY RIVER — CHLORINE CONTENT

remarkable observation is the high percentage of saturation observed during the third period, when the mean flow of the stream was only 1.5 million gallons daily.

The Pocasset River in Rhode Island has been chosen as an example of a stream grossly polluted with wastes from textile establishments, and exhibiting pollution, repurification and repollution throughout its course.

The river rises in Thornton, R. I., and flows about six miles to join the Pawtuxet River in the city of Providence. Near its source there is a large wool-scouring plant, whose wastes are treated by the acid process; below that a textile mill; and below that several hamlets. Farther below, the stream flows into a pond which supplies water for a cloth-finishing plant and a large printing, bleaching and dyeing establishment. Farther below the river flows through meadow land and then over a low dam into a short length of stream between the dam and its mouth.

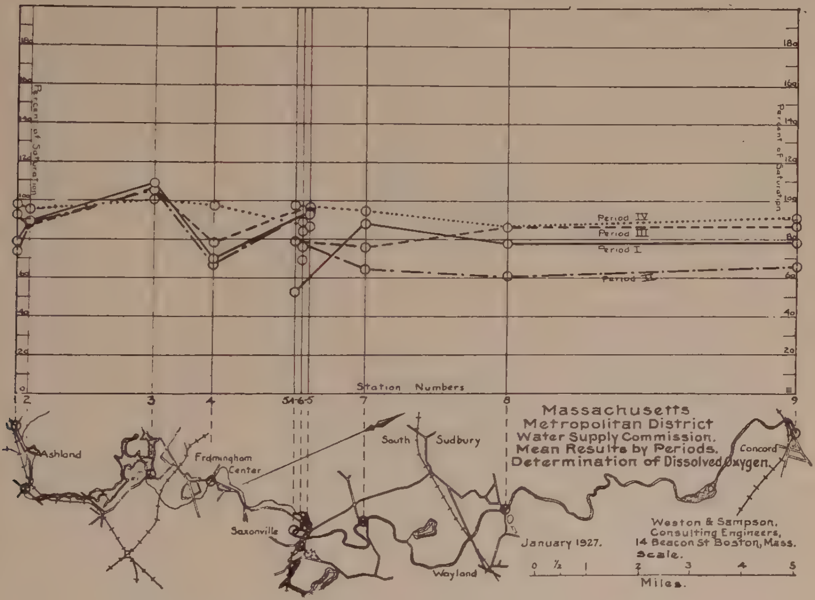

FIG. 3. — SUDBURY RIVER — DISSOLVED OXYGEN

The results of the determinations of color, oxygen consumed, dissolved oxygen and biochemical oxygen demand are given to illustrate the condition of this stream, both during the whole year 1928, and for the period from June to October of the same year.

The color, Fig. 4, increases gradually throughout the upper industrial section, and then remains fairly constant until it receives a fresh increment at the two finishing plants. Then there is a gradual decline due to dilution towards the mouth of the stream.

The oxygen consumed, Fig. 5, which is a measure of the organic matter, follows quite closely, so far as the incidence of polluting material is concerned, the curve showing the color. However, there is considerable reduction of the oxygen consumed (a measure of the carbonaceous matter) in the pond above the two finishing plants.

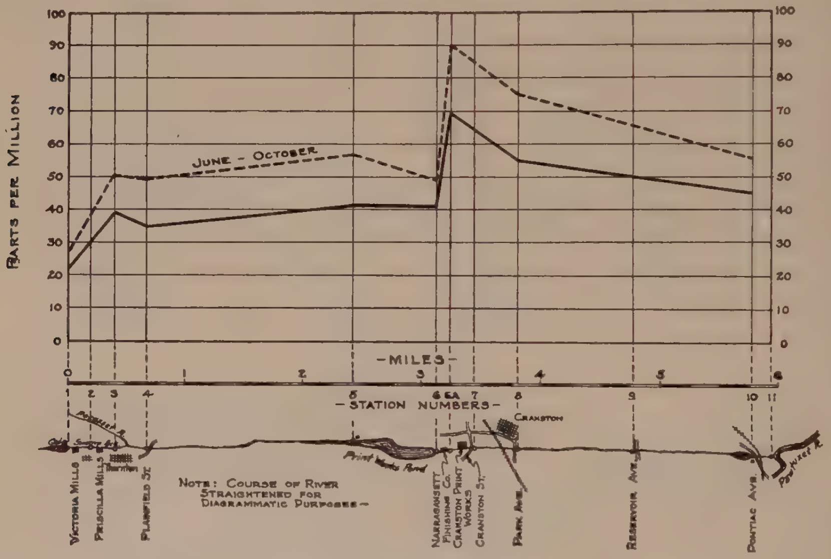

Fig. 4. — Pocasset River — Changes in Color

The dissolved oxygen is rightly taken as a measure of the condition of the stream. Streams which are deficient in dissolved oxygen become black and offensive, and those containing more than 30 per cent of saturation are to be sought for, as every public health engineer knows. The diagram, Fig. 6, shows that during the year, and on the average, there is a gradual reduction in percentage of saturation of oxygen from the upper stream to the pond. The water becomes regenerated in the pond, in going over the dam, and in the stretch of rapids below the dam. Soon, however, the effect of the discharge from the two finishing plants becomes evident; the oxygen becomes greatly

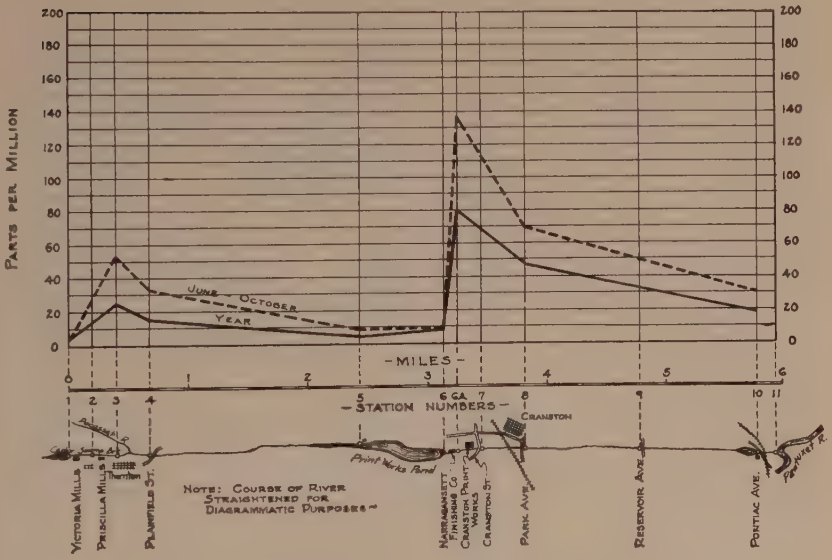

Fig. 5. — Pocasset River — Oxygen Consumed

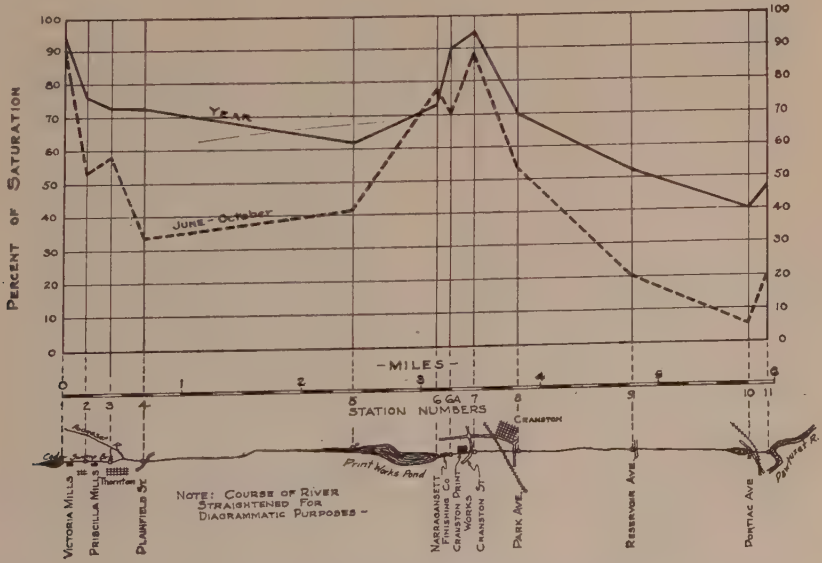

Fig. 6. — Pocasset River — Dissolved Oxygen

reduced on the average, and is nearly exhausted during the period June to October by the time the lowest dam is reached. Here there is a slight re-aeration, as the diagram shows.

Equally significant are the results of the determination of biological oxygen demand, as shown by the diagram, Fig. 7. These pertain to the part of the river below the print works pond only. The biological oxygen demand is a measure of the oxygen required to make stable the organic constituents of the water.

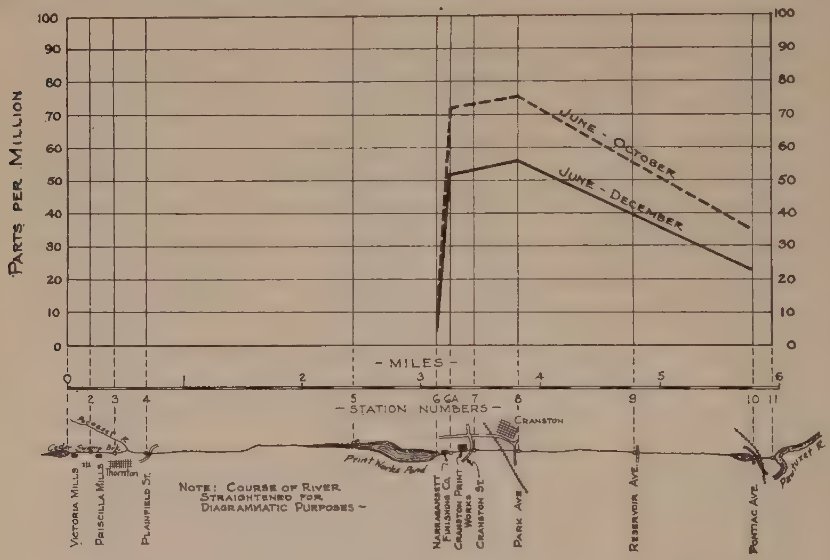

Fig. 7. — Pocasset River — Biochemical Oxygen Demand

Seasonal Changes

The seasonal changes in biological oxygen demand are as significant as the individual determinations, and the results of seasonal variations at the lowest dam are given to illustrate what may occur in a polluted stream. The diagram, Fig. 8, shows quite clearly that those determinations which vary with the dilution, *i.e.*, the turbidity, color and the oxygen consumed, generally indicate the highest concentrations in summer when the stream discharges are lowest. This is true of the alkalinity, also.

On the other hand, the dissolved oxygen was entirely absent during the period from July 15 to October 15, during which period the stream was offensive in appearance.

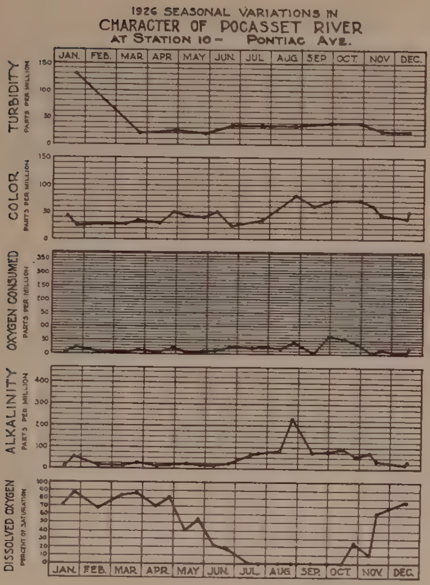

FIG. 8. — POCASSET RIVER — SEASONAL VARIATIONS IN CHARACTER IN 1926

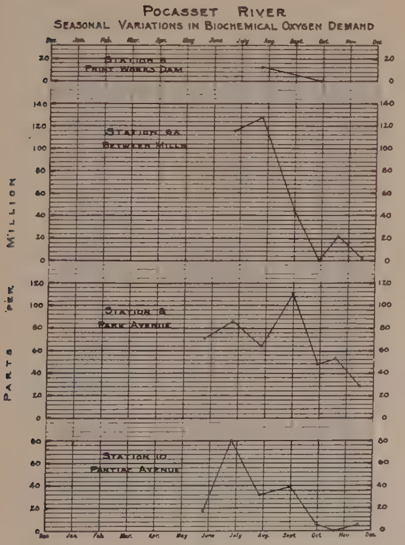

FIG. 9. — POCASSET RIVER — SEASONAL VARIATIONS IN BIOCHEMICAL OXYGEN DEMAND IN 1926

The seasonal variations in biological oxygen demand are shown in Fig. 9. The slight variations in the print-works pond are to be compared with the extreme variations in the streams below. It will be noted that the greatest concentrations of material requiring oxygen to make it stable are found between the two finishing plants and at the station a few hundred feet below the lowest finishing plant.

REMEDIES

A consideration of remedies for a condition which the above diagrams exhibit must begin with the stream and not with the sewage. Dilution is, of course, the basic method of disposal. Small streams may be prevented from becoming nuisances by adding sodium nitrate to supply deficiencies in oxygen. This method has been used successfully abroad and on the Neponset River in Massachusetts. Naturally the method is not applicable to streams of large discharge because of its cost The methods which would naturally follow are screening, subsidence with skimming, treatment on beds, and the activated sludge process, — methods similar to those used for treating domestic sewage.

Unfortunately the wastes from wool-scouring plants, bleacheries, dyehouses and print works are more difficult to treat than is domestic sewage. The fatty matter in wool-scouring waste clogs sewers and sewage beds, and it is usually imperative to treat the waste by the centrifugal process or by precipitation by acid before it can be passed to an ordinary treatment works.

Bleacheries discharge four wastes which are especially troublesome, namely:

1. The waste from kiers in which "gray" cotton cloth is boiled. This closely resembles some of the wastes from the paper industry. It is strongly alkaline and contains cellulose derivatives and ligneous matter. It is usually discharged intermittently. Consequently, its effect upon processes depending upon biological action is apt to be disastrous.

2. Spent bleaching liquors containing chlorine. Chlorine is a strong antiseptic, and while beneficial, as an addition to the stream, is detrimental to the operation of treatment works which depend upon biological action.

3. Chrome liquor. This results from the mordanting of cotton. It is acid and somewhat antiseptic.

4. Starchy wastes from the various finishing and padding processes. Modern finishing plants employ a great variety of starches, gums and sugars to improve the appearance of cloth. The processes using these products decompose rapidly with the production of lactic and butyric acids, a combination which is extremely difficult to treat by any known process.

The waste from most finishing plants and dyehouses may be separated into two classes, one of which may be discharged directly into the stream without detriment. This consists of clear wash waters and the like. These may amount to over 60 per cent of the total volume of waste. Because of the intermittent operation of the plant, basins cleaned by hand are usually more economical than those cleaned mechanically, although the latter are, of course, more convenient to operate and produce more concentrated sludges requiring less sludge-bed area.

In many cases subsidence alone, with dilution, suffices for the protection of a stream receiving bleachery waste. Subsiding basins should remove more than one-half of the suspended solids and over 97 per cent of the settleable solids contained in the raw waste.

The sludge in basins may be best cared for on sludge beds which may be either open or covered. The low temperature of the waste must be taken into account.

To purify the subsiding basin effluent is a difficult matter because of the antiseptic character of the waste, containing kier liquor, sour starch, chlorine and chrome liquor, and perhaps either excessively acid or alkaline during certain hours of the day.

Ordinary intermittent beds of sand may not be used in cold climates because of their liability to freeze, and even in warm climates beds of ordinary thickness afford too little opportunity for oxidation of the organic matter.

The best results in the practice of the writer's firm have been obtained with the combination of a primary trickling filter of coarse cinders, receiving the effluent from the subsiding basin, and a secondary intermittent cinder bed composed of screened furnace cinders passing through a screen with three-eighths-inch meshes, and receiving the effluent from the primary filter.

The results obtained by a plant of this kind are illustrated on the following diagram, Fig. 10. These were the average obtained at a plant in Rhode Island, one of the largest in the country, during the year 1926. The reduction in suspended matter and turbidity in the subsiding basins and the necessity for double filtration for its further reduction are evident, also the effect of double filtration upon the color and biological oxygen demand.

The activated sludge process has been suggested for the purification of textile waste, and the writer's firm conducted experiments at a large print works where this process is being compared with the method of double filtration, just mentioned.

The activated sludge process failed with this bleaching waste because the suspended matter was so light that sludge losses in the sludge separator were prohibitively large. Furthermore, by weighing the suspended matter by additions of clay the process could be made to work, but, of course, the addition of weight to the sludge just to make the process work was not practicable. This experience has been duplicated in New Jersey, recently, by other engineers.

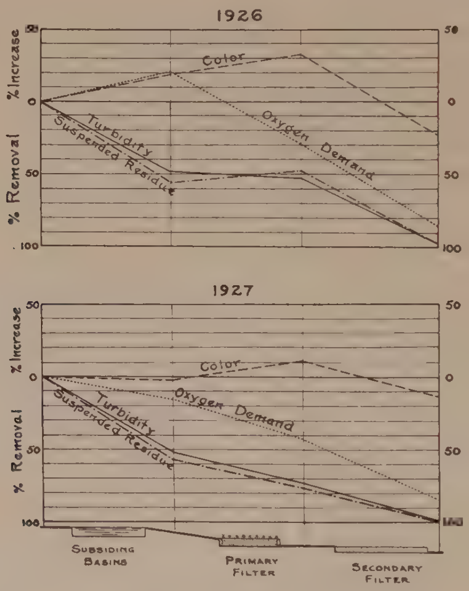

Fig. 10. — Progressive Changes in Character of Wastes at Various Stages of Treatment

Conclusions

The subject of industrial pollution is extremely important, not only for plants but for communities using the same streams. So far the data pertaining to the problem of purification of textile wastes are extremely limited, and it is hoped that increased appropriations may be placed in the hands of state authorities.

Problems involving industrial sewage should be considered from the standpoint of the stream, and not from the standpoint of the individual plant. Group treatment is extremely desirable, and the formation of conservancy districts or river boards is to be recommended.

Standards are difficult to establish, but it seems that an attempt should be made to maintain the dissolved oxygen at above 30 per cent, better above 50 per cent, of saturation at all times.

Not all textile wastes require purification, and great savings may be made by separating in the mill the harmless wastes from those which should be purified. In some plants these latter amount to 75 per cent of the whole volume.

Many streams require plain subsidence alone; others require treatment on filters. So far, single filtration has not been always effective, due to the antiseptic character of some of the wastes to be treated, or to the kinds of substances discharged.

While subsidence followed by double filtration has produced excellent results, the process is expensive, and it is unfortunate that the activated sludge process is not applicable to a waste with suspended solids of so low a specific gravity as that in certain textile wastes.

The data in this paper have to do with pollution by textile plants. Equally interesting are the problems of pollution by other wastes, such as those from pulp mills, tanneries, iron works and other chemical industries, but these are beyond the scope of this paper.

OF GENERAL INTEREST

HERBERT SPENCER

*By Edward Grossman**

Many engineers have risen to eminence in their profession to such a degree that even the blasé public hears of them. Many others have forsaken engineering to gain material success in business. We will consider an engineer who, forsaken by engineering, gained eminence in philosophy.

Herbert Spencer was born at Derby, England, on April 27, 1820. His father, a school-teacher, did not consider Herbert constitutionally strong, and for that reason did not send him to school until the age of eight or thereabouts. The boy exhibited a preference for botanical excursions over the countryside, and in this his father encouraged him, while at the same time teaching him his letters, arithmetic and such "natural science" as he deemed wise. Then Herbert was sent to a school kept by a Mr. Mather, who was a rather ineffectual teacher. It is to be feared that the future philosopher did not completely assimilate the plenitude of Latin and rhetoric administered to him.

In 1830 Uncle William took Herbert in hand. The youngster then made better progress. Owing to the training given him by his father, Herbert's reasoning powers were acute, so that the mechanical pedagogy of Mr. Mather created detest rather than desire for learning. Uncle William's method, on the other hand, being superior, showed results.

When he became thirteen years of age, Herbert was sent to Uncle Thomas at Hinton Charterhouse, near Bath, for additional schooling. Thomas Spencer guided his nephew through the mazes of Euclid, algebra, languages and rhetoric, besides the more advanced work of trigonometry, natural philosophy and mechanics. The mathematical and physical sciences filled the youth with delight, while the linguistics provoked dislike. At Thomas Spencer's Herbert studied about three years.

Herbert's father had an idealistic regard for his occupation and desired his son to be an educator also. At his request, therefore, the boy tried being a school-teacher for a while, but did not greatly care for it, and was genuinely glad when a letter from Uncle William, who had gone to London, asked him to come to the metropolis at once. Uncle William had secured for his nephew a position with Mr. Charles Fox, who was resident engineer on the London Division of the London & Birmingham Railway.

Herbert arrived in London on November 8, 1837, and reported immediately to Mr. Fox. Parts of the London Division were at that time incomplete, and beyond the completion of them there were certain matters, such as measuring up work, making surveys and similar details, which were turned over to young Spencer, who was started at a salary of £80 a year. Spencer stayed in London for six months, until the end of May, when he was transferred to Wembly, where he worked on the completion of the approach roads to Harrow Road bridge.

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* P. O. Box 9, Grove Hall Station, Boston, Mass.

When Spencer's work at Wembly was nearly completed, Mr. Fox made him an offer to go to Worcester, on the Birmingham & Gloucester Railway, where he would start as draftsman. Needless to say the offer was accepted, and on September 24, 1838, his work at Wembly being completed, Spencer left for Worcester.

The Birmingham & Gloucester, as it was then known, became soon afterward incorporated into the Midland Railways System. Its chief engineer at Worcester was a military gentleman, a Captain Moorsom. Spencer's companions in the railway office, while not objectionable on general grounds, did not behave decorously. To the new arrival it was inconceivable that men who sang ballads or whistled at their work, or dropped it entirely to stare out of the window at passing women, could come to a good end. He was wrong, however; sundry of them, whose careers he subsequently followed, turned out respectable men.

At first Spencer got into the bad graces of his companions because he was prone to criticize, owing to his superior educational advantages. Most of the chaps in the drafting room had only a rudimentary knowledge of mathematics and none of mechanics, so that they were unable to give scientific reasons for what they did. All they knew was to do as their superior officer told them. After a while, however, this hostility on their part wore off, and he was accepted as one of them.

While there he spent a good deal of his spare time on novel-reading, although he did some studying and investigating in what we call Descriptive Geometry and Mechanics of Materials. In the latter he had but indifferent success in his investigations, due, probably, to lack of apparatus.

During the latter part of 1839 Spencer was hard at work on plans for crossings and sidings at the various stations. For a little variety he acted as secretary to Captain Moorsom for a while, but toward the end of July, 1840, we find him at work in the field once more.

At Bomsgrove the railway crosses the highway over a bridge, which for some reason was unsatisfactory and was ordered replaced. Spencer was sent to superintend the work, which had to be done in four weeks. Owing to the short time available, it was not possible to await the casting of new iron girders for the bridge, so that such girders as were immediately available were used. The young engineer hit on an expedient which is best told in his own words: "These girders were, however, too short to span the width of the road obliquely, and the result was that a framework, partly of these girders and partly of strong timber balks, had to be made. I was a little nervous about it, but it proved strong enough." Truly, there were giants in those days.

During the next seven or eight months he traveled back and forth on the Birmingham & Gloucester, usually superintending construction, while in his spare time he rode his naturalistic hobby by collecting fossils. The railway was almost completed, however, and his engagement thereon was coming to a close. On April 25, 1841, he bid good by to the railway which he had helped build. He rejected the offer of a permanent post in what would now be termed the mechanical department as assistant engineer of locomotives, because he considered it would be a waste of his time.

He returned to Derby, where he did some studying of architecture and worked on his electro-magnetic engine. In April, 1842, a tributary to the River Derwent, which flows through Derby, overflowed its banks and produced in the main street a flood of six feet or more. Spencer wrote a report on the flood, which was published by the Town Council, and suggested a preventive remedy. The latter, however, involved such expensive engineering that it was not adopted.

During the year or two that followed Spencer contributed a series of letters "The Proper Sphere of Government" to the "Nonconformist," besides essays on various political and ethical matters. He was also drawn into the suffrage movement which at that time was agitating the public (only men holding a certain amount of property were eligible to vote at the time, and it was desired to extend the privilege to all males). He continued this until about 1843, when the movement for a time ceased.

In 1843 Spencer went to London to see if he could obtain employment in engineering. He worked for a time as assistant to a Mr. Prichard, who had little technical ability and much presumption, helping him with the plans of a couple of docks and on a book on "Bar-Harbors" (artificial harbors, or basins) which was so poorly written that it required thorough editing.

Although he had written several articles in the "Civil Engineer and Architect's Journal," and had good recommendations because of his work on the Birmingham & Gloucester, yet in the year and a half that he remained in London Spencer was unable to make a new connection, owing to his inability to push himself. He returned to Derby.

The active part he had played in the complete suffrage movement two years before resulted in his being offered a position in Birmingham as sub-editor of the "Pilot," a newly established organ published by the Complete Suffrage Union. This he occupied six months when Mr. Hughes, one of his chiefs on the Birmingham & Gloucester, asked him to assist in surveying for a branch to Wolverhampton. The work was to take not more than a month, so the young editor was able to obtain a leave of absence and returned to his profession. Although he did not know it at the time, he was to remain in engineering for more than the month, and his separation from the "Pilot" was a permanent one.

The work on the Wolverhampton branch lasted well into May, 1845. After its completion, Spencer went to work for Mr. Fox, but left him after a time because the latter had asked him to do certain things which Spencer had not agreed to do.

He soon, however, obtained a position with Mr. Prichard, who was planning a railway from Northampton to Worcester. Mr. Prichard, who was rather visionary, had a good many other railway schemes in his mind and on paper, but a hard-hearted Parliament did not accept them, and because of failure to obtain the enabling act, they all fell through. Late in 1846 Spencer's career as an engineer ended.

In his "Autobiography" Mr. Spencer admits that he is not sure whether or not he would have been a good engineer. He had the inventive ability and a tolerable amount of technical training; but lacking a certain kind of tact in his character, he was unable to ingratiate himself with his superiors, so that men inferior to him obtained preference.

Even in engineering, good-fellowship counted more heavily than ability.

For the two years following, Spencer worked on some inventions of his and on political articles, but not getting anywhere until 1848, when he became sub-editor of the "Economist," which position he held until 1853, when he resigned so that he could devote his time to writing for the reviews and on his books. Some of the best known of his works, with their respective dates of publication, are: "Social Statics," 1850; "Principles of Psychology," 1855; "Essays" (3 volumes, 1858, 1863, 1885); "Principles of Education," 1861; "System of Synthetic Philosophy" (in 10 volumes, begun 1860, completed 1896); Autobiography (2 volumes), 1904 (posthumous).

Spencer was the philosopher of the great scientific movement of the nineteenth century in which Darwin, Huxley, Wallace and others took part. As a biographer says, "He tried to express in a sweeping general formula the belief in progress which pervaded his age, and to erect it into the supreme law of the universe as a whole." No doubt Mr. Spencer was on the right track, yet because he lived at the beginning of an epoch of unparalleled scientific activity he could not possibly sum up and estimate its total production.

The "System of Philosophy" is an heroic attempt of a synthesis of all scientific knowledge. It describes the Knowable in terms of the mechanical conceptions of matter, giving a rather materialistic coloring to his philosophy. There is the other class of knowledge, the Unknowable, to which he does not apply the system.

While to the professional philosopher Spencer's system may not be long-lived, yet "it is fruitful as a source of suggestion." However that may be, England and America joined in honoring the great philosopher of the age.

Herbert Spencer died in Brighton, England, in 1903.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

MAY 15, 1929. — The regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall and was called to order by the President, Frank E. Winsor, at 7.15 P.M. Two hundred members and guests were present.

The Secretary reported the names of those elected to membership today by the Board of Government:

Grade of Member: Philip E. Bodemer,* Morris Cohen, Howard C. Holden, Wilfred H. Shields.*

Grade of Junior: Elmer E. Forslind, William B. Hilton, Charles Kerins, Herbert E. Randall, Jr.

The President announced the death of the following members of the Society: John E. L. Monaghan, died April 29, 1929, a member since December 17, 1919; Edward B. Waite, died November 3, 1928, a member since April 21, 1915. He stated that committees would be appointed to prepare memoirs.

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* Transfer from Grade of Junior.

The President reported that the Board of Government had voted to omit the regular June meeting in order to join with the New England Water Works Association in their outing at Swampscott on June 18, 1929, to be held at the New Ocean House.

The President then presented the speaker of the evening, James W. Rollins, Past President of the Society, and Vice-President of the Blakeslee-Rollins Corporation, who gave a talk on the "Pier Construction for the Mid-Hudson Bridge at Poughkeepsie, New York."

This bridge is being built under the direction of the Department of Public Works of the State of New York, and it is of the long span, suspension type, including two piers in the river, the span between them being 1,500 feet. These massive piers of concrete are each about 60 feet wide and 130 feet long, standing in about 60 feet of water, and the easterly pier extends to 135 feet and the westerly pier to 115 feet below low water.

The open caisson method was used in sinking the caissons for these piers. The westerly caisson was sunk without serious difficulty. The easterly caisson, however, penetrated a stratum of treacherous clay, and when about 10 feet into this material the huge caisson slipped without warning and finally tipped to an angle of about 45 degrees, leaving only 7 feet of one edge out of water.

The righting of this 12,000-ton caisson was the problem which was the most interesting, and demonstrated the ingenuity of method, the patience of performance, and final success of the contractor in saving this huge structure.

Numerous lantern slides and a series of moving pictures added greatly to the interest and value of the paper.

Following the presentation of this paper a number of questions were asked and a general discussion on the subject was held.

Meeting adjourned about 9.15 P.M.

EVERETT N. HUTCHINS, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

[June 20, 1929]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

CHASE, RUSSELL CUSHING, Stoneham, Mass. (Age 22, b. Dorchester, Mass.) Is a graduate of Northeastern University, 1929. During co-operative periods has worked for the city of Medford, engineering department. Refers to *H. B. Alvord, C. O. Baird, J. W. Ingalls, W. E. Nightingale.*

MORGAN, FRANCIS RING, Lawrence, Mass. (Age 29, b. Lawrence, Mass.) Graduate of Massachusetts Institute of Technology in 1922, with degree S.B. in civil engineering and S.M. in 1923. Worked as Junior Engineer with United States Geological Survey in Ohio from July, 1923, to June, 1924; transitman for Lockwood, Greene & Co., July, 1924; assistant in civil engineering department at M. I. T. from August, 1924, to June, 1925; inspector for Pennsylvania Highway Department from June, 1925, to January, 1926; with Massachusetts Department of Public Works from January, 1926, to date; now junior civil engineer, Division of Highways. Refers to *J. B. Babcock, H. D. Chase, Morris Cohen, G. A. Scott, Hale Sutherland.*

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DEATH

Henry F. Bryant . .	June 16, 1929

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FOUNDED 1848

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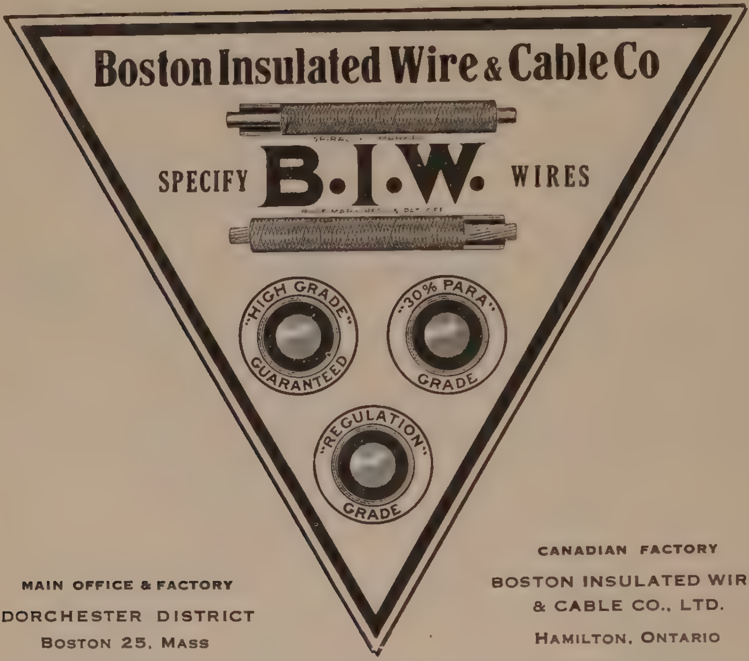

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